NOVEMBER 27, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY

AN AMERICAN AVIATION PUBLICATION

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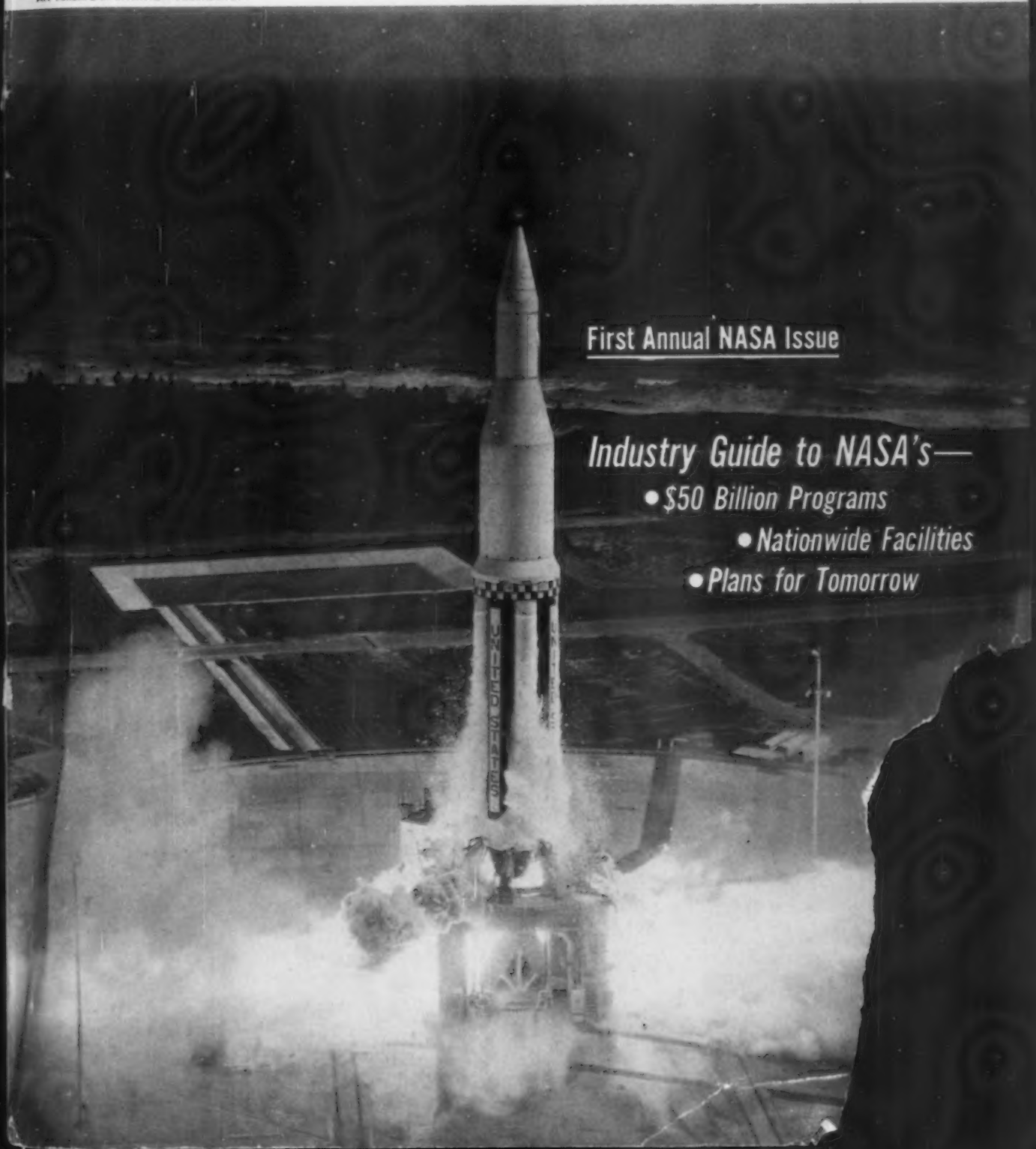

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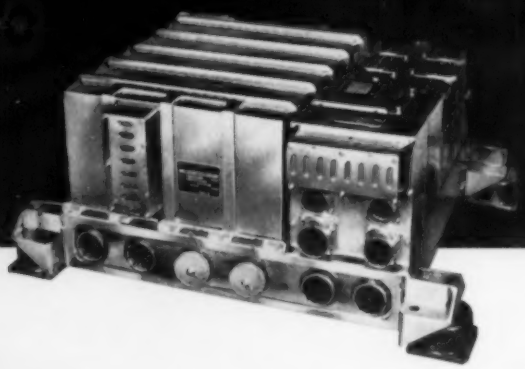

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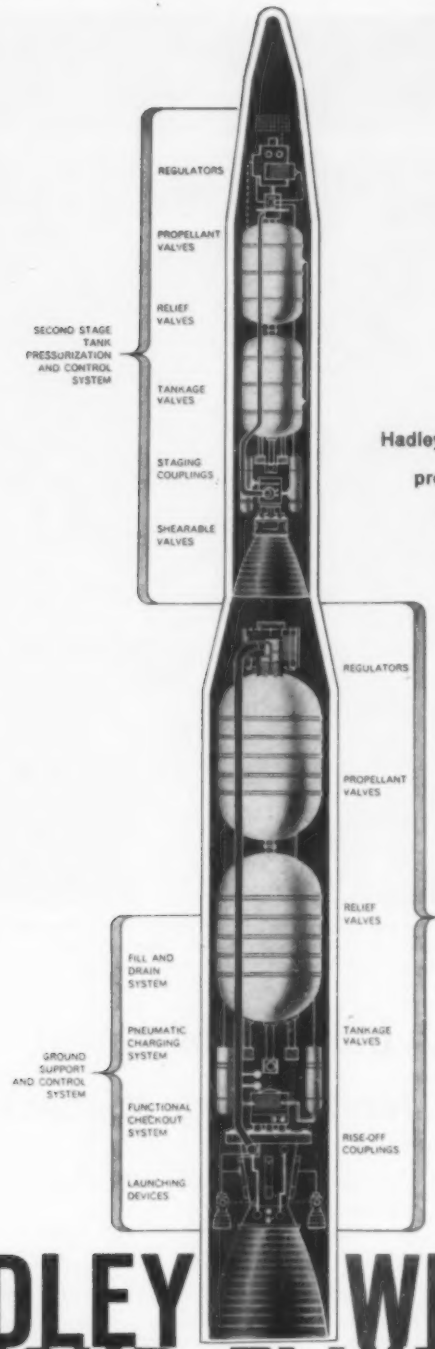

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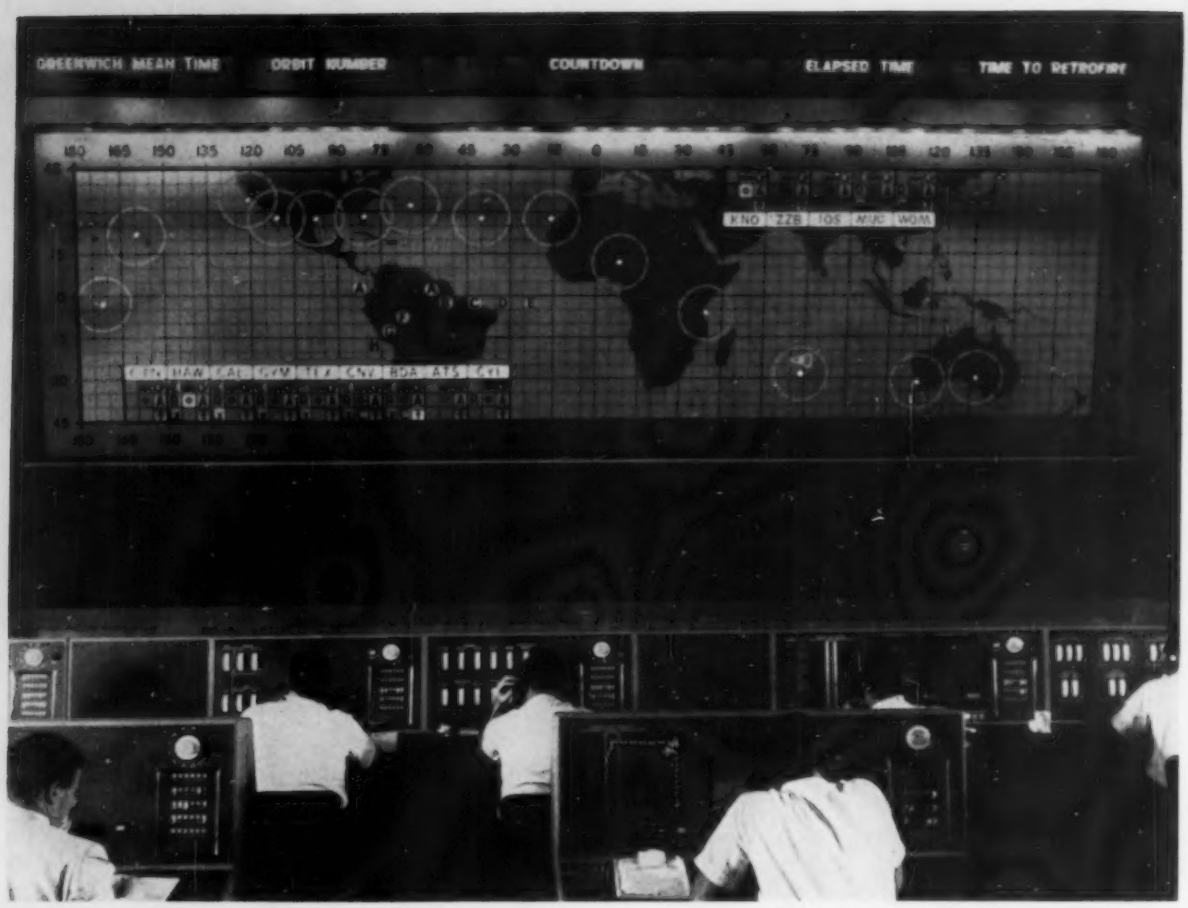

In Mercury Control Center room at Cape Canaveral, designed under supervision of Bell Telephone Laboratories, NASA flight controllers make all vital decisions concerning a Mercury mission. Large map displays equipment status at tracking and communications sites, preferred recovery areas, the position of the capsule and its "immediate impact point."

Bell System manages building of global communications network for Mercury spacecraft

On September 13, National Aeronautics and Space Administration first achieved the orbital flight of an unmanned Mercury spacecraft, using a new world-wide communications and tracking network.

Soon, will come manned orbital flight.

The Bell System has played a large role in the development of this scientific project.

Western Electric headed an industrial team, on which Bell Telephone Laboratories also played an important part, in building the world-wide network of tracking and monitoring stations.

This 60,000-mile communications route, the bulk of which is teletypewriter and telephone circuits, ties together 17 tracking and instrumentation sites with the Goddard Space Flight Center in Greenbelt, Md., and the Cape Canaveral Mercury Control Center.

As a Mercury capsule orbits over the area covered by each site, the far-reaching communications network immediately begins feeding information received from the capsule with clockwork precision. So fast and efficient is this communications system, it takes only seconds for data to start flowing from any site through Goddard to Canaveral!

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 9, Number 22 November 27, 1961

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THE COVER

Successful Oct. 27 takeoff of Saturn C-1 symbolizes NASA's gathering drive toward the moon, subject of this First Annual NASA Issue of M/R. Report starts on p. 39.

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† U.S. Reg. Pdg.

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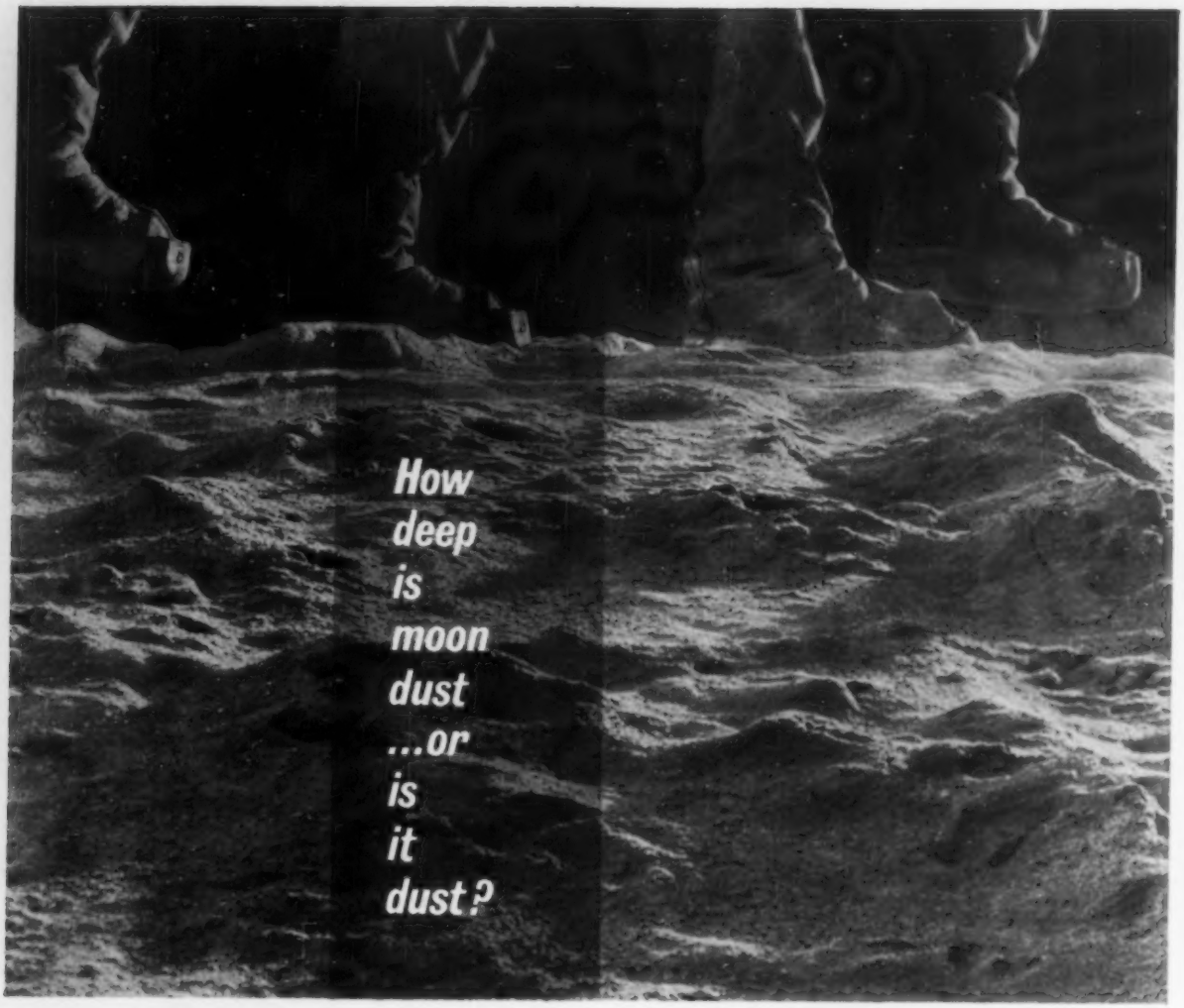
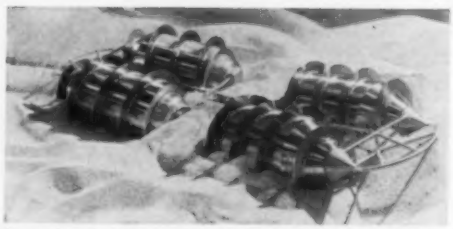


GM's DSD seeks an answer!

Scientific studies are now under way in GM's Defense Systems Division to determine the most efficient configurations for lunar-roving vehicles. Major factors under investigation include composition of the lunar surface together with the effects of large temperature ranges, lunar gravity . . . no atmosphere or humidity. Research in our Soils Laboratory on probable lunar conditions has led to a number of promising designs. Unusual studies like these, unusual facilities and unusually capable men present a great challenge and opportunity to scientists and engineers who are qualified to make a solid contribution at any level. DSD is now, as always, searching for new talent in these areas.

Scientific areas now under study: ▪ Aero-Space Operations ▪ Sea Operations ▪ Land Operations ▪ Biological Systems ▪ Technical Specialties



Moon-Roving Concept—This early model moon rover utilizes the principle of the Archimedes screw . . . and is just one of a number of vehicle types under study for known lunar conditions.

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memo from the publisher

YOU ARE HOLDING the largest weekly issue ever published by this magazine. Its size is indicative of the importance of its subject.

As NASA Administrator James Webb points out on p. 40, the National Aeronautics and Space Administration is engaged in what many people consider the most ambitious endeavor in U.S. history, the effort to land a team of American astronauts on the moon. To achieve this and its other important scientific goals, the space agency within the next few years will be spending an estimated $4 billion annually with industry.

NASA's growth this year has been explosive, so explosive that many in the industry have found it difficult to keep up with the changes. The large-scale expansion and reorganization of the agency is, however, of prime importance to those who are doing business with it—as well as those who hope to do business with it. We felt one of the most useful tools we could provide for the industry we serve was an up-to-date guide to NASA.

During the past two months, the editors of MISSILES & ROCKETS have been touring NASA installations throughout the nation. Every NASA center was visited, some more than once, some by several editors. Detailed information was obtained on budgets, facilities, programs and procurement practices. The need for new equipment and techniques was explored with the men closest to the programs. You will find in the pages that follow not only useful planning information but a great many little-known facts about the space agency.

Did you know . . .

—That the Ames Research Center uses about 12-million cubic feet of helium a year?

—That every hour *Explorer XII* is in orbit means an hour of data reduction for Goddard Space Flight Center?

—That Langley Research Center can trace its involvement in the missile field from its 1918 experiments with a modified Curtiss-Wright aircraft used as a drone?

—That photographic supplies at Lewis Research Center are purchased by W. T. Hodges?

—That the budget at the Flight Research Center at Edwards AFB is expected to double next year?

—That the cost of launch vehicles for Goddard satellites does not come out of the Goddard budget but out of NASA Headquarters' money?

—That Lewis Research Center is looking for a commercially available alloy which will contain liquid potassium and sodium?

These and many other facts about the space agency are contained in this issue. Every effort has been made to fully inform you on NASA programs and to help you in doing business with an organization that is expected to spend some $40 billion with the industry in this decade.

Here is one way to use this guide:

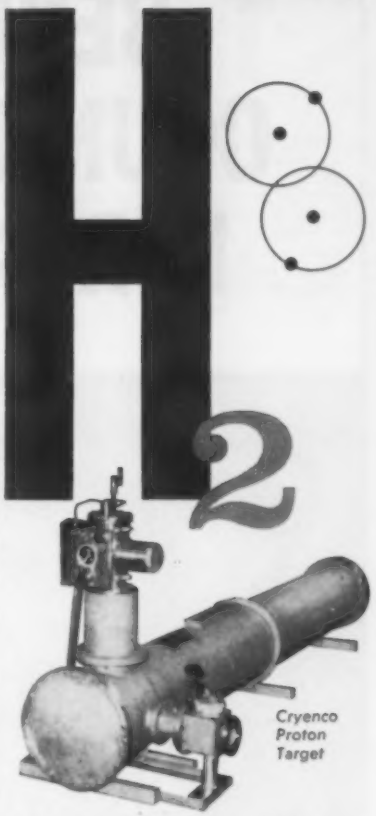
Study the overall NASA budget and its programs in the beginning of the issue. Then if you are, for example, in the electronics field, turn to the section on electronics. There you will find a rundown of what NASA is doing in the electronics field and where. Let us say your particular interest is in data handling. You will discover that there is a major interest in this at the Goddard Space Flight Center, as well as several other centers. Turn then to the individual articles on these centers. They will tell you what each center's budget is, what its facilities are, where its fields of interest lie. Its procurement practices and even the names of its procurement officers are provided.

We believe you will find this issue useful as a reference throughout the year. Combined with the extensive weekly coverage of NASA in the months ahead, it will keep you well posted on one of the government's major purchasing agencies.

Incidentally, it also is worthy of note that with this issue, M/R's net paid circulation passes 35,000—a gain of some 5000 since the first of the year.

Edmund C. Bleiberg

CRYOGENICS



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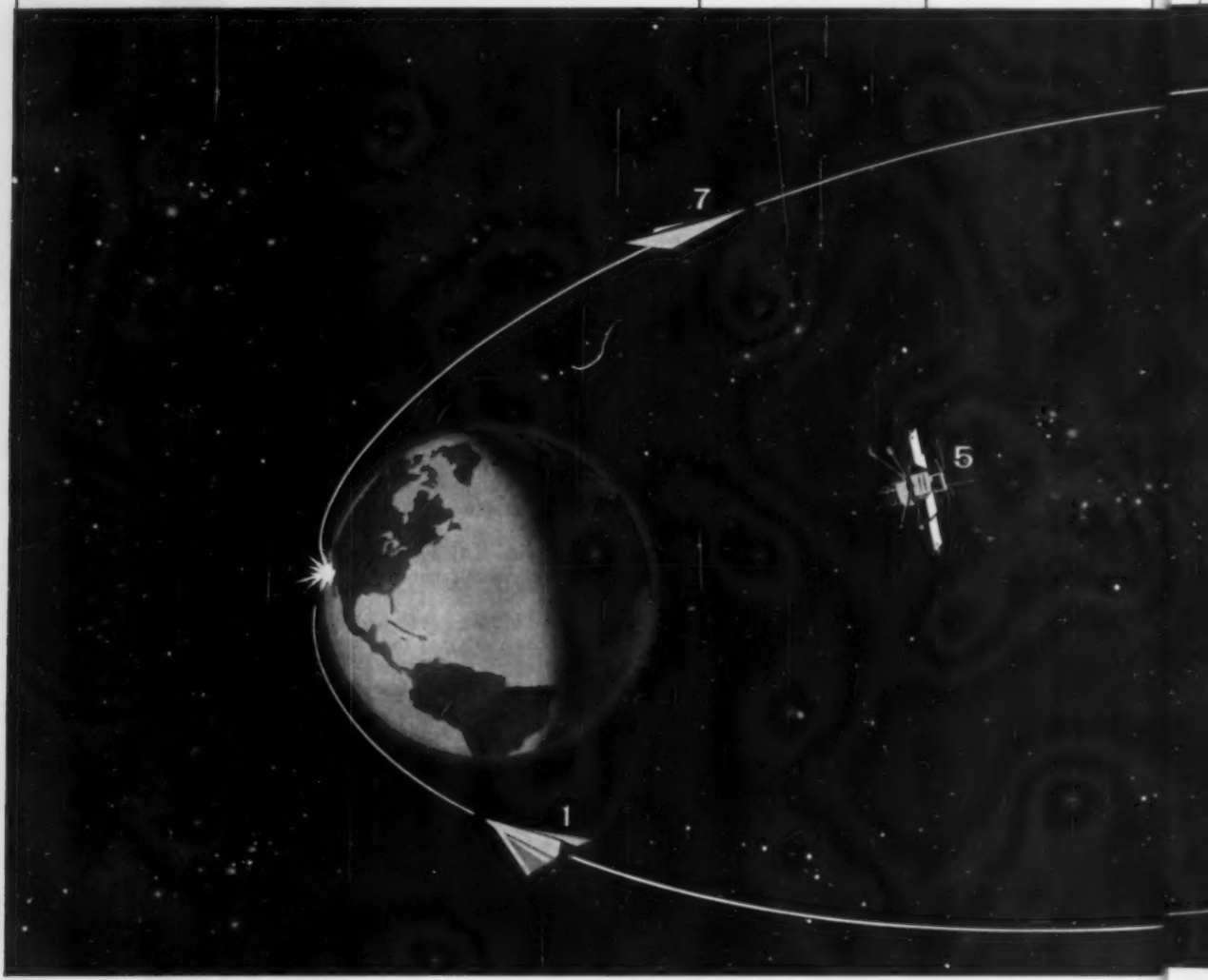
BENDIX COUNTDOWN FOR SPACE

7

PNEUMATIC CONTROLS: Hot gas equipment is being developed for space control subsystems using rotary and linear actuation, reaction jets, and pneumatic computation. A complete subsystem is now being built at E-P under USAF contract.

6

SELF-ADAPTIVE CONTROL SYSTEM: Capable of measuring dynamic sensitivities and adjusting feedback gains in stable fashion without sensing external environment. Automatically blends control of aerodynamic surfaces and reaction jets. Being developed under USAF contract.



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5

SATELLITE CONTROL AND STABILIZATION: Eclipse-Pioneer has total in-house capability for producing spacecraft attitude-control systems. In production: ADVENT reaction wheels. In development: sun-sensors and star trackers.

4

STAR TRACKER SYSTEM: A system incorporating multiple star tracking heads, designed to operate without a protective dome in the environment of space; digital readout accuracy of ±5 arc seconds.

3

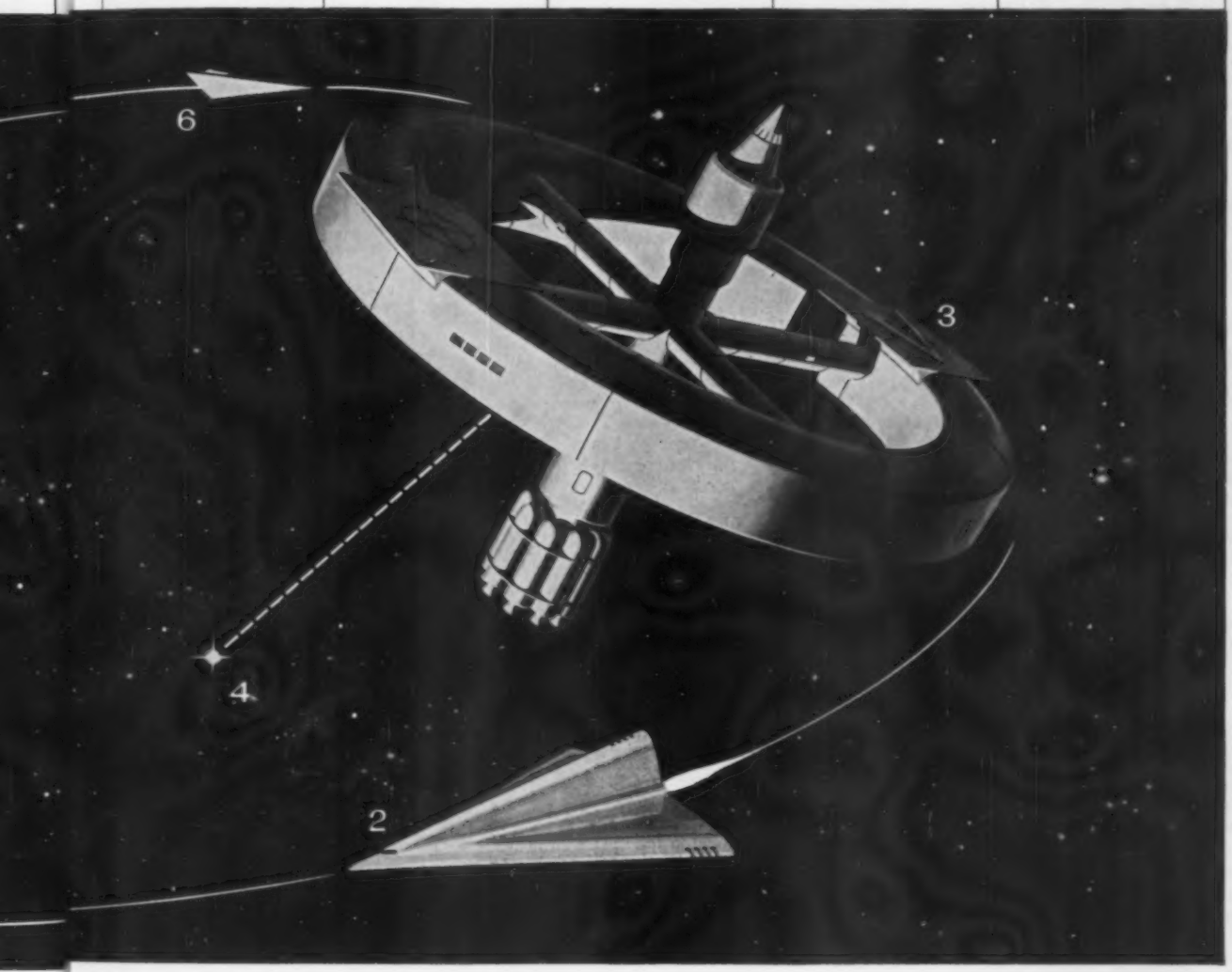
SPACECRAFT RENDEZVOUS COMPUTER: Complete solid-state mechanization for analog and digital airborne computation of navigation, guidance, and attitude-control circuitry required at time of rendezvous. Digital computation at 10 megacycle rate.

2

ADVANCED DISPLAYS AND CONTROLS: Development currently in progress. Human-factor display studies directed toward rendezvous, re-entry, energy-management. Electronic and optical devices will present correlated data with minimum panel space.

1

LETDOWN, APPROACH, LANDING: Safer, more reliable letdown and landing systems—such as inertially augmented flare and runway-alignment, computers, advanced instrumentation (including real-time displays)—are now being developed, flight-tested.



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letters

Liquid vs. Solid Costs

To the Editor:

The article "Costs Bolster Case for Solid Booster" (M/R, Nov. 13, p. 24) considers the problem from an obviously biased viewpoint. This type of cost comparison ignores a principal advantage of the liquid systems over solid systems—the potential economy obtained by recovery and re-use.

There can be little doubt that if boosters are recovered and re-used the hardware cost will become an insignificant factor in the basic costing equations, and the significant parameter for evaluating booster costs in an extensive space program will be the cost of propellants.

Based on present or even extrapolated propellent costs of $1.00 per pound for solid propellent vs. $0.5 per pound for liquid propellants, it is apparent that the logical direction for future boosters is towards the development of reliable "airline type" recoverable liquid boosters.

Despite the fact that this conclusion has been repeatedly confirmed by several investigators, industry effort and government support toward achievement of this goal has remained at a comparatively low level.

B. Friedman
Eastview, Calif.

Non-Profit Dilemma

To the Editor:

I thought your Oct. 16 editorial, "Enough of This Non-Profiteering," was well stated. Private industry continues to face the dilemma of coping with more and more non-competitive government-sponsored organizations which do not face evaluation of performance on a competitive basis.

Richard H. Olson
Vice President
Sunstrand Corporation
Denver

To the Editor:

Who will profit from the non-profits? This question is "bugging" industry, the military, and government. Even armchair pundits are waxing eloquent—not to mention the sallow-faced curators of the status quo who automatically condemn anything new.

Depending on who you are, the non-profits are good or they are bad. For instance, industry believes the non-profits will not be able to justify the demand for their "specialized" talents, a demand which was in fact generated by the Air Force. American corporations, particularly the giant missile builders, possess at present adequate systems management capability. Perhaps a supposed preoccupation with stockholders, dividends, new contracts and gross sales, etc., has given government the impression that with industry it's profits first and performance second. Consequently the Pentagon, doubting the capability of underpaid civil servants and annoyed by profit-taking by systems managers, slaps wrists by attempting to create a corporate utopia; i.e., top-drawer executive talent, big salaries, no stockholders, unlimited capital resources, and complete isolation from the harsh, cold realities of business life. From within this test-tube environment the non-profits have only to provide managerial and technical "advice" to the customer, who pay a fixed fee, regardless of what grade information is being generated.

The Air Force, Army, and even NASA may profit from heeding their respective managerial oracles. After all, many top names and recognized authorities have been lured into the non-profits, hoping perhaps to precipitate a management millenium. They will undoubtedly be right more often than not.

The taxpayer, including aforementioned pundits and curators, will take another financial flogging if only because the non-profits are one hundred percent overhead.

The biggest loss to be incurred as a result of non-profiititis is that of public confidence in the free enterprise system which, according to the latest propaganda, will catch and over take the largest and most "profitable" non-profit organization the world has ever known.

If, in fact, industry has been found deficient in producing "state-of-the-art" management teams, it should take stock immediately and place added emphasis on this phase of space systems creation. If on the other hand industry is being unjustly by-passed by the armed services who, goaded by traditional rivalries, are trying desperately to "outmanage" each other, the Pentagon should step in and override this senseless stockpiling of management talent and return systems management to private enterprise where it belongs.

Walter H. Trask
Santa Clara, Calif.

To the Editor:

I always read your editorial, since your un-gimballed position, whether one agrees with it or not, is at least refreshing. Occasionally, I find one which is even less interesting than the self-backslapping advertisements so profusely displayed in M/R's pages. "Enough of This Non-Profiteering" (M/R, Oct. 16), however, was fine. I hope your well taken point is equally well taken by those in charge.

Jack F. Cully
Albuquerque, N.M.

Trieste Gets Its Data

To the Editor:

With much pleasure we have received 25 copies of your very interesting Annual Missile/Space Encyclopedia, and we thank you very much for your kindness and splendid gesture.

For your information, we have sent copies to 23 of the better students of our astronautical course. . . . Two copies will remain in this Center to assist us in our studies.

We have received from the following persons and organizations many offers of pamphlets, technical books and data:

1. NASA's George C. Marshall Space Flight Center (Mr. W. H. Stafford sending a very important technical note about satellite launchings).

2. NASA Headquarters, publications, photographs and books.

3. Mr. Donald J. Ritchie, supervisor mathematician, vice-chairman of the Institute of the Aerospace Sciences, sending a very nice and interesting booklet on design of ballistic rockets.

4. *San Diego Union*, asking for a copy of the Russian book (from which we earlier obtained drawings and data on U.S. missiles).

5. Mr. Chester Zeich, ARS member, asking information about our course.

6. Mr. Horace Westbrooks, asking for a postal stamp of Italian firing rockets, for a philatelist.

Hoping you are pleased, I thank you again very much for your interest in our organization.

Fabio M. Berto
General Secretary
Astronautics Sciences and Space Technology Diffusion Center
Trieste

Mr. Berto first wrote M/R (Sept. 4 issue, p. 52) to ask for help in obtaining information on U.S. space programs. He said that USIS in Trieste had been unable to supply such material. Lowell Bennett, Director of the Office of Public Information, U.S. Information Agency, wrote a letter in reply (M/R, Oct. 23, p. 7) detailing the lectures, films, photos and pamphlets on U.S. space activities that his agency had provided in Trieste and elsewhere in Italy. We don't know why Mr. Berto and USIA had their difficulty, but we are glad in any case that the Diffusion Center is accumulating more information.—Ed.

Dots and Dashes

To the Editor:

Mr. J. B. Wilson's letter to the editor (M/R, Oct. 30, p. 6) appeared quite logical and straightforward until my mental arithmetic failed to come up with the same answers that he obtained. Initially it appeared that the ratio for take-off thrust to take-off weight in Soviet boosters given as 1—3 may have been inverted preventing me from taking off. After wondering if Mr. Wilson really knew what he was talking about it finally dawned that M/R's proof reader had caused the problem by replacing the decimal point in 1.3 with a dash.

Robert T. Carr
Cmdr USN
Executive Officer
Naval Space Surveillance System
Dahlgren, Va.

(Continued on page 181)

He's solving a real estate problem

This AMF engineer's job is determining how best to move big missiles off shore for launching. Should they be floated out horizontally, flooded to an upright position, and then launched? Or, would it be more feasible to barge them out? Might they be moved to or assembled on "Texas Towers," or would a causeway or simply land-fill be the answer?

Behind the project is our shrinking real estate at launching sites, plus the hazards inherent in launching Saturn-sized missiles (and the coming, nuclear-powered missiles) near other installations. Off-shore launching may be the answer.

Feasibility studies of all types are an AMF specialty. What kind of remotely controlled machinery is required to service nuclear-powered aircraft? What kind of habitation could be built on (or under) the surface of the moon? What sort of machines (manned and unmanned) could survey the moon's surface without, for example, falling into a fissure? What is the best way to assemble a space station? All these are problems AMF engineers are presently investigating.

If your problem is the first of its kind, AMF will not, of course, have met it before. But AMF's long experience in accepting totally unique challenges gives it an advantage enjoyed by few other organizations concerned with ground support, launchability and space environment. To get further information write American Machine & Foundry Company, 261 Madison Avenue, New York 16, N. Y.

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Dr. Edward C. Welsh / exec. sec. / National Aeronautics and Space Council / N. Y. Times, Oct. 8, 1961

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The Countdown

WASHINGTON

NASA 10-Year Plan—Revised

Officials at NASA are putting together a radically updated version of the old 1960 NASA 10-year plan for exploration of space. The plan—scheduled to be ready for submission to Congress in January—will take into account the great acceleration of the Manned Lunar Landing Program that is pushing the expected date of reaching the moon up to 1967, instead of the early 1970's.

Polaris Sub Goal Rising

The Navy appears to be raising its long-range goal for the *Polaris* fleet. Until recently, the magic number has been a total of 45 *Polaris* submarines. Now the number is being tentatively raised to 50. That would give the Navy a total of five nine-ship squadrons and possibly five additional submarines for NATO.

Mercury Monkey Shot Readied

The launching of a monkey-carrying *Mercury* capsule into orbit has been rescheduled for sometime within the next week. Some Administration officials are understood to have proposed that the shot be skipped and that a manned capsule be launched instead. But the proposal has been rejected. As a result, the earliest a manned capsule could be launched is mid-January. February is a more likely date.

Zeus 3-Stage Launch Coming

The first hot launching of all stages of a *Nike-Zeus* now is expected to take place by the end of the year. So far, only two stages of the three-stage antimissile missile have been fired in test launchings from Pt. Mugu, Calif., and at White Sands. The three-stage launching will take place at Pt. Mugu.

LAW in Production

LAW antitank missiles are beginning to roll off the production line. The Hesse-Eastern missile is the newest of the Army's light, solid-fueled tactical weapons. It is expected to be deployed with troops in the near future.

INDUSTRY

Hercules to Get Polaris A-3 Award?

COUNTDOWN hears that Hercules Powder's Allegany Ballistic Laboratory has beaten Aerojet-General in the competition for the *Polaris A-3* second-stage production contract. Announcement of the award is imminent. Hercules proposed a glass filament-wound case to help boost the range of the bird to 2500 miles.

Gel Solid Contract Expected

The Air Force is expected to award a feasibility contract to Atlantic Research for work on the company's gel solid concept. The contract would be part of the Air Force's expanding interest in solid propulsion. Atlantic Research's gel solid propellant is designed so that it can be transported to a launching pad by tank truck and poured into motor cases.

Electronics Shopping List Due

The Pentagon's new Defense Supply Agency is expected to have a decision by early next year as to what electronic components it will buy for all military services. A proposed "shopping list" for DSA is being put together by a special study group headed by Air Force Maj. Gen. Charles Root. The list is scheduled to be submitted to the Defense Department about Dec. 1.

Front Office Intelligence

Former Navy Assistant Controller Norwood P. Cassidy has taken over as head of Servonics Inc., Alexandria, Va. . . . North American's Space and Information Systems Division is adopting the Navy's computerized PERT (Program Evaluation and Review Technique) for all major contracted and in-house programs. First use: NASA's *Saturn S-II* stage. . . . Litton is acquiring Aero Service Corp., a $10-million photogrammetric and geophysical survey concern. . . . After losing its second *BIOS* capsule in the Pacific Nov. 18, NASA posted a $25 reward to anyone finding it washed ashore. The capsule is worth $250,000.

INTERNATIONAL

AS 30 vs. Bullpup (Cont.)

Backers of France's *AS 30* air-to-surface missile are contesting reports (COUNTDOWN, Nov. 6, p. 9) that *AS 30* appears to have lost out to *Bullpup* as armament for the NATO F-104 fighter. They claim *AS 30* compatibility tests are "progressing satisfactorily" with the aircraft and no trouble is expected in firing tests to be held shortly. Moreover, they say *AS 30* has the edge with Britain's RAF, West Germany's Luftwaffe and the French Air Force.

Moving Westward

An advance space projects group dropped by Hawker Siddeley earlier this month may head for America. Dr. William Hilton and several members of his team are expected to take positions with Hughes Aircraft.

Rumors from Russia

There are reports from Moscow that the Russians now expect to try a manned circumlunar flight early next year—and that they are pushing for a manned landing on the moon in 1964.

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SCHOOLROOM FOR ASTRONAUTS

On America's drawing boards and in the laboratories are two, three and five-man spacecraft, space platforms and manned lunar craft. The goal is interplanetary flight. Eventually, lifetimes may be devoted to a single space adventure.

But man must conquer near space before he goes afar.

Ready to serve as the trainer for future astronauts is NASA's Project Mercury spacecraft. This compact, one-man vehicle now carrying the first Americans into space is an astromedical laboratory to test man's reactions to this new environment. But the Mercury spacecraft can easily serve as a readily available and efficient schoolroom for future astronautics students making their first leaps into space.

Months of ground training will be necessary for coming space explorers. Then will come trajectory flights to experience weightlessness and spacecraft control. Earth-orbital flights will acquaint the future astronauts with spacecraft control, celestial and ground observation, re-entry techniques, artificial atmosphere and other environment concepts.

Only after he has mastered the "one-room schoolhouse of the space age" will the astronaut be ready to man a deep space vehicle.

Employment opportunities exist for engineers and scientists. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.
Write: Professional Placement,
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The mysteries of space . . . untapped resources of limitless knowledge defying existing concepts of the physical and social sciences . . . soon to alter man's image of self and the universe.

Intra-galaxial communications, sensing, and processing systems developed by ITT Kellogg support the space program's approach to the myriad ramifications of present and long range space exploration.

KELLOGG • communications systems department
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Parts molded of J-M Thermomat® meet the extreme service demands of the missile age

Here is a unique new molding compound in sheet form that offers many advantages in rocket and missile applications. Cured parts and components molded of J-M Thermomat—such as the collar you see here—have already proved they can meet the most extreme service demands.

Because these parts withstand high temperatures, offer maximum resistance to ablation and erosion... they are currently being used as an erosive flame shield for protecting critical guidance and stabilizing mechanisms on operational missiles.

Thermomat's high strength-to-weight ratio is another important advantage, permitting rocket weight to be reduced and fuel capacity increased. Thermomat parts also have a high modulus of elasticity.

In sheet form, this non-woven asbestos-phenolic molding compound is unusually conformable and pliable, making assembly quicker and easier. Molders like the way joints and seams work together as readily as putty . . . and the fact that one man can handle lay-up, saving hours of time.

Non-fillouts are at an absolute minimum, even on complex configurations. Asbestos fibers are free-flowing during molding, resulting in a uniformly reinforced part. This versatile product lends itself to both low and high press molding cycles, thus keeping inventory and waste to a minimum. Any machining of cured Thermomat parts to precision tolerances can be easily accomplished with standard metal-working equipment.

Thermomat is supplied in sheets 14" wide . . . approximately 12' long ...and ⅛" thick. Thermomat in other dimensions may be supplied on request. Molders are invited to write for Technical Bulletin TX-10A and a generous free sample in order to try this remarkable molding material for themselves. Write Johns-Manville, Box **359,** New York 16, N.Y. In Canada: Port Credit, Ont.

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THERMOMAT

JOHNS-MANVILLE JM PRODUCTS

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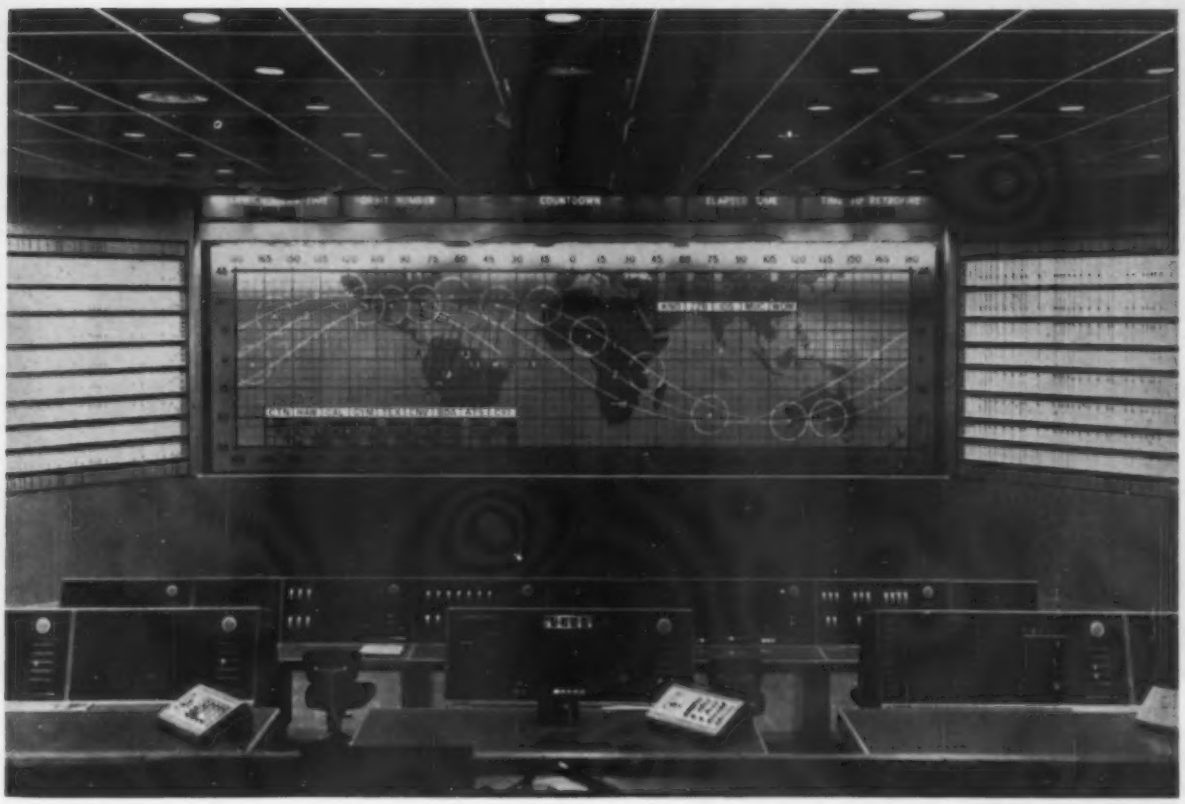
Lifeguard station for a

MAN IN SPACE

The vital Cape Canaveral nerve center for Project Mercury, the U.S. program to put a man in space, was designed and built by General Dynamics | Electronics. ■ Display information about flights is fed to the operations room from computers and from a world-wide network of tracking and telemetry stations. One wall of the 40 by 60 ft. operations room is a large map display, visually summarizing all pertinent information about the flight. It shows the capsule moving along its orbital flight path around the earth and will also show the location, range and status of all ground based equipment and communications links. ■ The operations room contains display consoles presenting information to the Flight Director, Chief Flight Surgeon, Capsule Communicator, Flight Dynamics Officer and other decision-making personnel. ■ For information on how General Dynamics | Electronics can help solve your data/display problems, write to Dept. B-68, Information Technology Division, General Dynamics | Electronics, 1895 Hancock Street, San Diego 12, California. Telephone CYpress 8-8331.



GENERAL DYNAMICS | ELECTRONICS

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Why Lockheed-California started building its space-travel task force four years ago

Back when satellites started making the headlines, it was clear that *man* in space was *next*—and that it would take a lot of groundwork to develop the capability to put him there.

That's why four years ago Lockheed-California anticipated this need and formed its SpaceCraft Organization—the group that has grown into one of today's specialized and knowledgeable man-in-space task forces.

From the beginning, the Lockheed-California SpaceCraft Organization has devoted its efforts specifically to the problems of transporting *men* from one point to another in space. This called for capability in almost every phase of space technology—solar physics, geophysics, astrophysics, biophysics, and radiation hazards—as well as the development of space vehicles and manufacturing techniques.

Today, the Lockheed-California SpaceCraft Organization stands 700-strong—experienced and ready to undertake important projects of the man-in-space age. This group has already made significant contributions to space-

craft technology such as the original Space Ferry concept, SLOMAR/SMART projects, and other major orbital vehicle concepts. Unique man-in-space manufacturing techniques of the Lockheed-California SpaceCraft Organization include the development of high-strength, lightweight, radiation-cooled spacecraft structures.

For more information about the Lockheed-California SpaceCraft Organization, write Mr. Robert A. Bailey, Lockheed-California Company, Burbank, California.

LOCKHEED CALIFORNIA COMPANY

BURBANK, CALIFORNIA

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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Precision welding systems...
Cryogenic gases...
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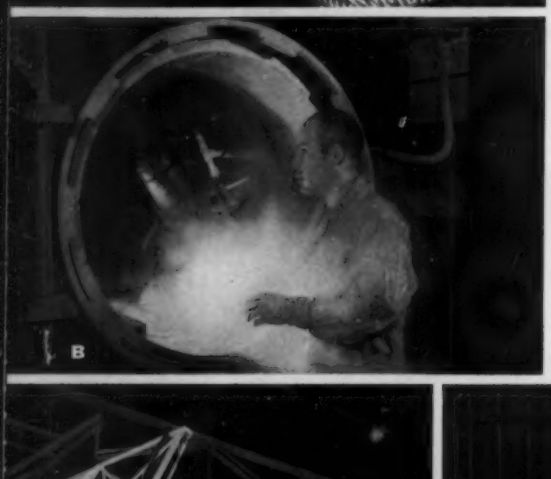
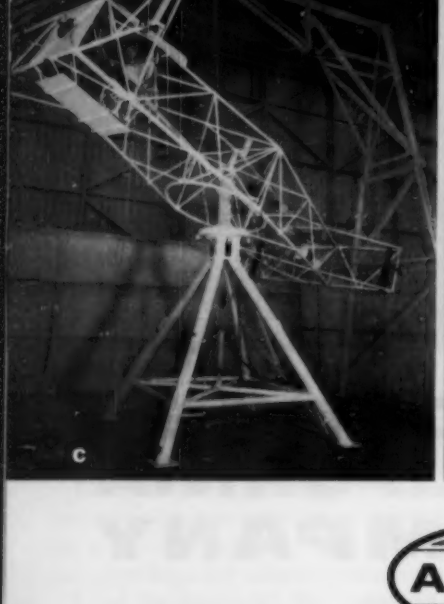
Air Reduction helps to speed America's Space Programs

A


B

In America's development of both space vehicle fleets and the new defense arsenal Airco's part is wide ranging, complex, continuing. It includes not only the supplying of gases, equipment and know-how for the projects noted here, but also many other assignments . . . such as the development of a life support breathing system for astronauts . . . the production of gases 99.998% pure for semiconductor crystal growing furnaces . . . the engineering of radical equipment for high precision, high speed joining of metals. If you design or build spacecraft, rockets, missiles, aircraft, or ground support systems . . . Airco can provide constructive help.


C

D

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AIRCO®

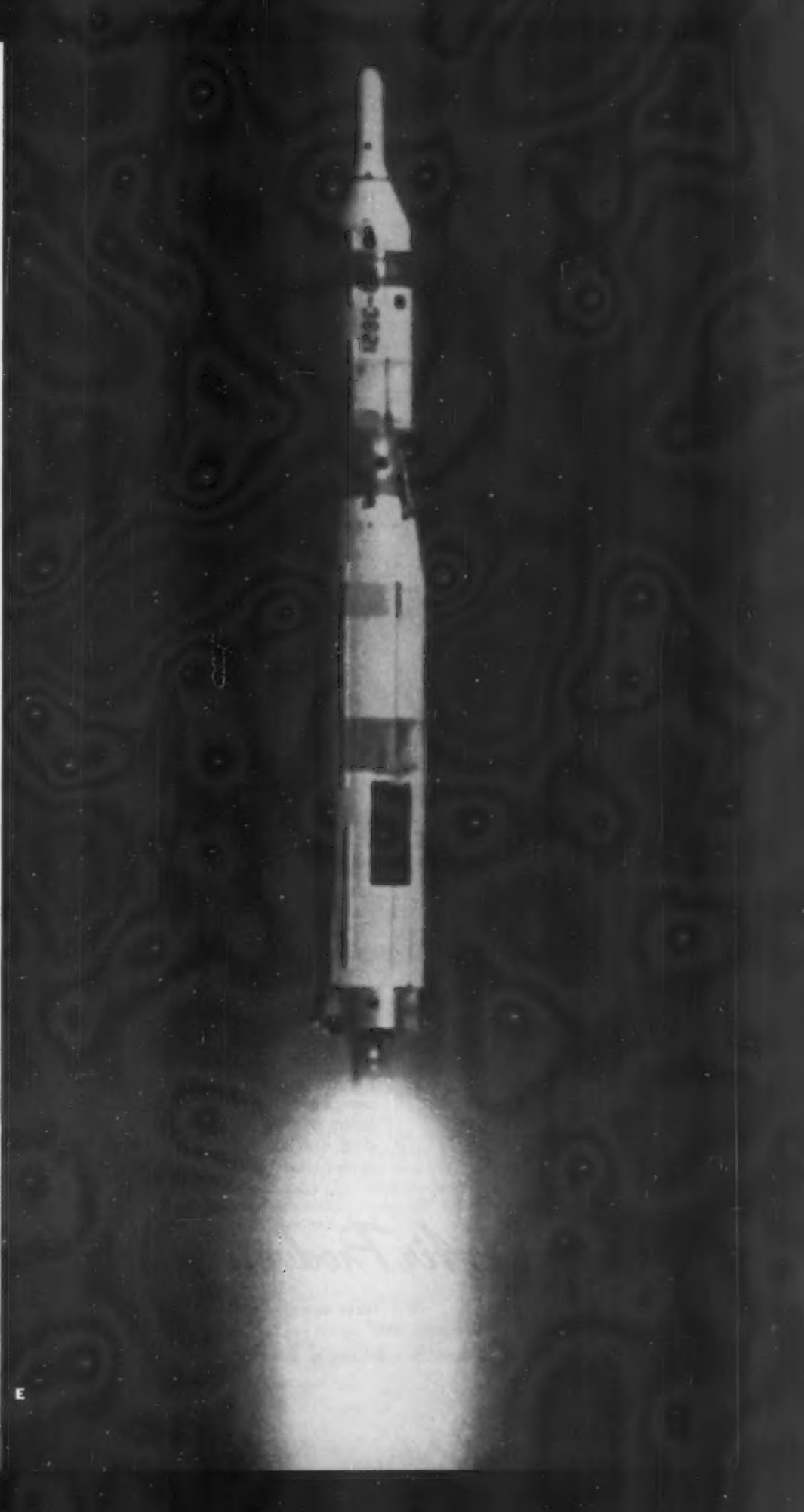
A Airco's electron beam welder is opening new avenues of application for the exotic metals. These metals —columbium, molybdenum, tungsten and other refractory metals have been hard to weld. Now more and more companies engaged in aerospace programs are discovering that these unusual metals yield excellent fusion welds under the high efficiency bombardment of the electron beam welder.

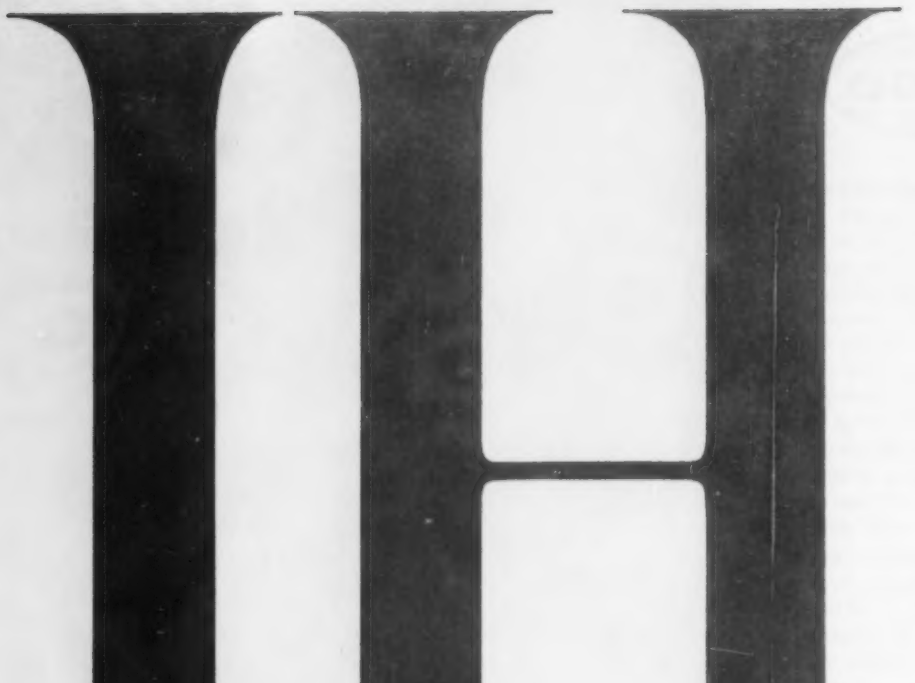
B Airco nitrogen for Cryogenic valve testing. To help assure the efficiency of liquid oxygen valves for missiles, Stewart-Warner utilizes Airco liquid nitrogen in its environmental test chamber. Airco's long experience in environmental testing and the high purity of Airco products have led to a manyfold increase in demand for the company's gases.

C Reaction-control simulator developed by Boeing Airplane Company to help provide the "feel" of a space vehicle in flight. In this, one of many aerospace applications of Airco gases, blasts of Airco nitrogen from jets slowly pitch, roll and yaw the simulator.

D The mighty Titan. Airco's now famous dome welding equipment joining the thin aluminum "orange peel" sections of the Titan's fuel tank top. Designed and engineered by Air Reduction's Special Products Department for the Martin Company, it is the largest precision tool installation in the United States.

E 1/20/61 launch of the Titan at Patrick AFB, Florida. Paneled skin of the first and second stages was Airco Heliwelded. Similar Airco equipment is finding broad application in the aerospace field.





Air Products pioneered in the application as well as the production of liquid hydrogen . . . the ultimate fuel . . . for missiles and rockets. Examples: the test facilities for KIWI, and test facilities for even newer missiles. Air Products possesses missile propellant system capabilities few others can match. If you have a problem in propellant systems, look to Air Products first for the answer.

Air Products and Chemicals
INC.

NEW DIMENSIONS IN GAS TECHNOLOGY

DEFENSE & SPACE DIVISION: General Office: Allentown, Pa. DISTRICT LOCATIONS: Dayton, Ohio; Washington, D. C.; Los Angeles, Calif.; Orlando, Florida.

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A cross-section of the 40 subsystems incorporating 3500 electronic parts which go into TIROS III are framed by two satellites. All components must be thoroughly tested, precisely integrated and must function perfectly if the satellite is to perform successfully.

NASA's Hurricane spotting TIROS III maintains projects' fine performance record

With the successful launching of TIROS III, meteorologists for the first time will see the total cloud formations and measure the radiative energy balance of hurricanes which plague the eastern coast of North and Central America each year. For TIROS III was launched at this time for precisely this purpose. From information gained from TIROS III, meteorologists may learn much more about the birth and life cycle of tropical storms.

TIROS III DESIGN

Although the spacecraft configuration is essentially the same as the previous two highly reliable TIROS satellites, TIROS III has two wide-angle cameras and the National Aeronautics and Space Administration has placed new omnidirectional IR sensors aboard to measure thermal radiation from the earth and sun.

THIRD OF A FAMOUS FAMILY

TIROS III is the third of a highly successful series of experimental weather satellites which were developed, along with the associated ground equipment, for the NASA, under contract with the Goddard Space Flight Center, by RCA's Space Center. All of them have established "firsts" in the United States' space program.

TIROS II established a longevity record for a complex satellite. Still operating after nearly eight months and over 3300 orbits, TIROS II has transmitted over 34,000 photographs to the ground. Aside from its impressive meteorological achievement, historians may well point to this long-term performance as the first to prove that a satellite system could operate reliably for so many months in a space environment thus proving the feasibility of operational satellites.

TIROS I was the first satellite, carrying advanced television equipment, which sent photographs of the earth's cloud cover to meteorologists. From TIROS I's 23,000 photographs, meteorologists found that satellites could be used for weather observation and analysis. The pictorial information is particularly useful in the two-thirds of the world from which few or no weather observations are now available.

CONNOTATIONS FOR THE FUTURE

The TIROS series has proved beyond a doubt that the peaceful uses of space will benefit all mankind. Six nations participated in the utilization of information from TIROS II and more will take advantage of TIROS III. RCA is also already at work on the camera systems and space power supply for NIMBUS, the next generation of meteorological satellites.

Latest RCA Defense Electronics accomplishment—an RCA 110 computer has been procured by NASA from RCA Data Systems Division, Van Nuys, California, to check out SATURN test vehicle. The most challenging opportunities in space electronics are at RCA. Contact Employment Manager, RCA Defense Electronics Products, Camden, N. J.

RCA

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RADIO CORPORATION OF AMERICA

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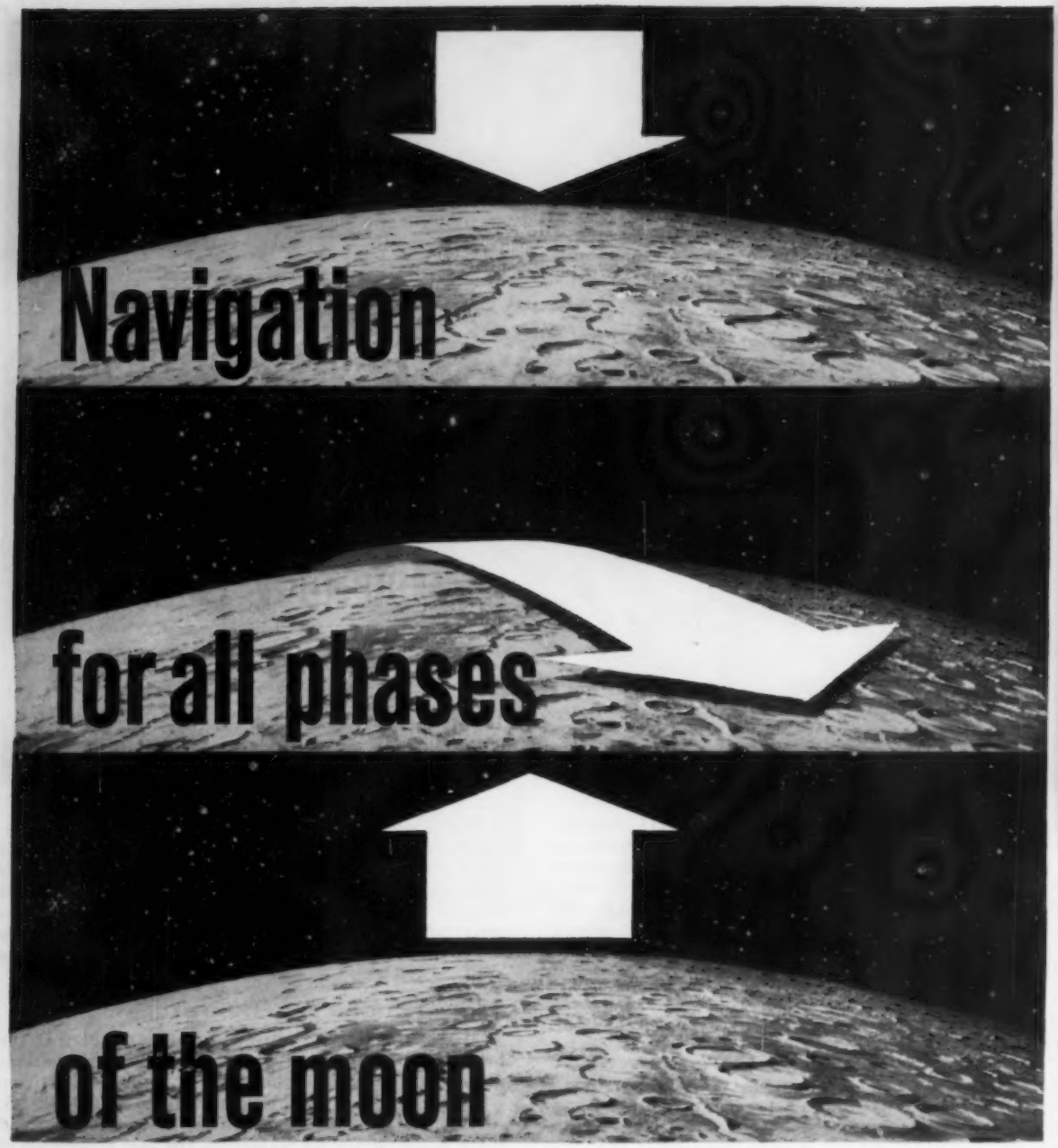

"Manned lunar probe" means a successful round trip . . . and poses a host of problems. Among others, navigation.

To get to the moon or a planet, move on its surface, and return to earth is a full-scale systems requirement, calling for the highest order of navigation, guidance and control sophistication.

In all phases of space navigation—particularly the tougher ones of rendezvous guidance, mid-space station assembly, movement over the surface of planets, return vehicle remote launch, recovery and landing — the Sperry Rand Systems Group offers a maximum technological and management capability.

This capability includes deep space tracking radars, rendezvous, orbital and mid-course injection nets, space command and control centers, attitude control systems, real time data processing, and sophisticated recovery systems to guide a vehicle through the difficult final approach, controlling its speed and maneuvering it to a precise landing site. Other systems include optical communications and navigation, pilot displays and controls, auxiliary power and automatic checkout. General Offices: Great Neck, New York.

SPERRY RAND SYSTEMS GROUP

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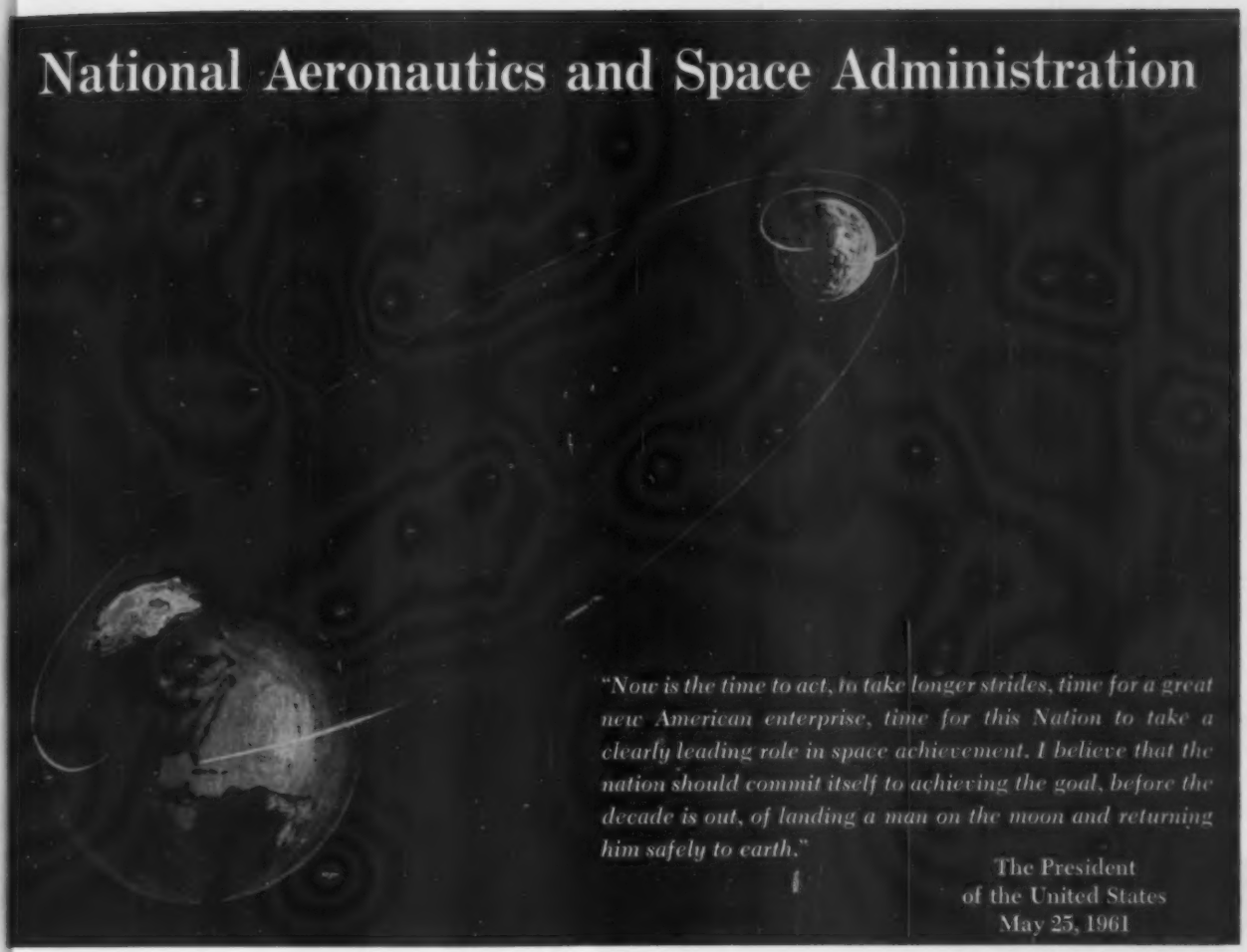
National Aeronautics and Space Administration



"Now is the time to act, to take longer strides, time for a great new American enterprise, time for this Nation to take a clearly leading role in space achievement. I believe that the nation should commit itself to achieving the goal, before the decade is out, of landing a man on the moon and returning him safely to earth."

The President
of the United States
May 25, 1961

The nation has committed itself to accelerate greatly the development of space science and technology, accepting as a national goal, the achievement of manned lunar landing and return before the end of the decade. This space program will require spending many billions of dollars during the next ten years.

NASA directs and implements the nation's research and development efforts in the exploration of space. The accelerated national space program calls for the greatest single technological effort our country has thus far undertaken. Manned space flight is the most challenging assignment ever given to mankind.

NASA has urgent need for large numbers of scientists and engineers in the fields of aerospace technology who hold degrees in physical science, engineering, or other appropriate fields.

NASA career opportunities are as unlimited as the scope of our organization. You can be sure to play an important role in the United States' space effort when you join NASA.

NASA positions are available for those with degrees and experience in appropriate fields for work in one of the following areas: Fluid and Flight Mechanics; Materials and Structures; Propulsion and Power; Data Systems; Flight Systems; Measurement and Instrumentation Systems; Experimental Facilities and Equipment; Space Sciences; Life Sciences; Project Management.

NASA invites you to address your inquiry to the Personnel Director of any of the following NASA Centers: NASA Manned Spacecraft Center, Hampton, Virginia; NASA Goddard Space Flight Center, Greenbelt, Maryland; NASA Marshall Space Flight Center, Huntsville, Alabama; NASA Ames Research Center, Mountain View, California; NSA Flight Research Center, Edwards, California; NASA Langley Research Center, Hampton, Virginia; NASA Wallops Station, Wallops Island, Virginia; NASA Lewis Research Center, Cleveland, Ohio; NASA Headquarters, Washington 25, D. C.

Positions are filled in accordance with Aero-Space Technology Announcement 252B.

All qualified applicants will receive consideration for employment without regard to race, creed or color, or national origin.

Chrysler May Build 50 S-I Boosters

NASA launched its *Saturn S-I* booster production program last week with the award of a multimillion-dollar contract to Chrysler Corp.

The initial contract to Chrysler calls for building 20 of the clustered 1.5-million-lb.-thrust rockets for more than $200 million.

However, insiders estimate the production run may hit 50—running up the contract cost. (The cost-plus-fixed-fee contract extending through 1966 is the first in a series of key contracts in the *Apollo* Manned Lunar Landing Program detailed on page 46 of this special NASA issue.)

NASA announced the contract award Nov. 17, ending a hot competition among seven missile/space firms. The winning Chrysler proposal includes assistance from Aerojet-General Corp. in static testing of stages. Aerojet also will provide launch support at Cape Canaveral.

Other competitors for the big prime contract were Boeing, Ling-Temco-Vought, Ford Aeronutronic, Avco, Northrop and Lockheed.

The *S-I* boosters are powered by eight Rocketdyne (North American Aviation) H-1 engines. The booster is 81 ft. high and 22 ft. in diameter.

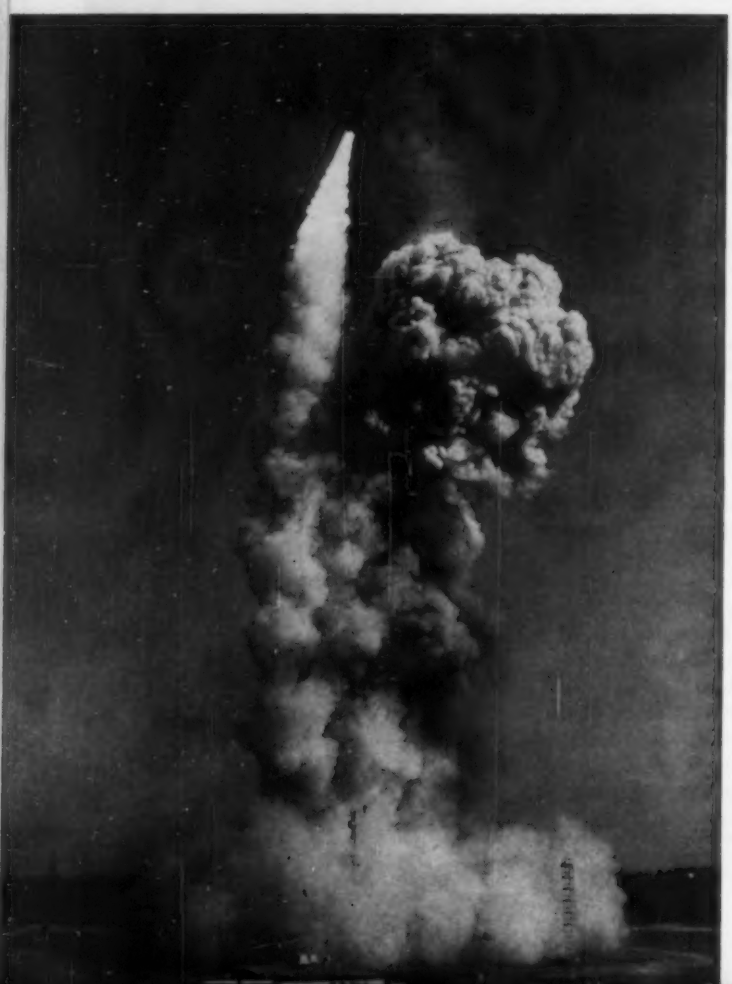
The first 10 *S-I's* are being fabricated for testing at NASA's Marshall Space Flight Center, Huntsville, Ala. These are the prototypes of the *S-I's* which Chrysler will produce at NASA's huge new plant at Michoud Arsenal, 15 miles east of New Orleans.

The fabrication plant is currently being rehabilitated for *Saturn* production. NASA is evaluating proposals from some 35 companies to select a contractor to maintain and service the plant.

The first *Saturn S-I* unit turned out by Chrysler will be shipped to Cape Canaveral in early 1964. After maximum production is reached, one unit per month will be produced.

The space agency said that some Chrysler personnel would be assigned to the Michoud plant in the next two months. By mid-1962, some 1800 people would be employed at the plant under the contract; peak *S-I* employment of about 2400 would be reached during the first half of 1963. ■

Firing from Silo Expedites Final Phase of Minuteman Tests



SUCCESSFUL first launching of a *Minuteman* ICBM from an underground silo this last week opened the way for a planned acceleration of the last stages of the missile's test program.

The Air Force still feels that it has a good chance of meeting its schedule of having the first operational *Minuteman* deployed on Montana prairie by mid-1962.

The first 50-missile squadron is expected to be deployed at Malmstrom AFB, Mont., by the end of 1962. A total of 12 squadrons—600 missiles—are expected to be deployed by early 1964.

The successful launching on Nov. 17 was the fifth in the *Minuteman* test series at Cape Canaveral. The Air Force box score to date: Three successes, one partial, two failures.

A geyser of smoke shot with flame poured from the silo in the first second after the missile ignited below the surface of the ground. Then the 58-ft., solid-fueled ICBM roared skyard through the smoke and plummeted some 3000 miles down the Atlantic Missile Range. The missile when operational will have a range of 5500 nautical miles.

Before launching, the *Minuteman* was suspended in the 90-ft.-deep silo on a metal ring hung from the walls by metal straps. This arrangement will better enable the missile to withstand a near miss in a nuclear attack.

The launching was the second attempt at firing an untethered missile inside a silo. The first attempt last August ended when the second stage of the missile ignited prematurely seconds after the missile cleared the top of the silo. ■

Soviets Claim 100-Megaton Warheads—Hint at Stockpile

Russia continued to rattle its rockets this week with the boast that Soviet missiles are armed with 100-megaton warheads.

It was the first time that Russia had claimed to have packaged its nuclear superbombs in operational warheads.

Moreover, the Russians hinted broadly that they have a sizable stockpile of the big weapons.

Meantime, a series of other East-West military developments and disclosures took place:

—The British Institute for Strategic Studies said sharply revised intelligence estimates give the United States an edge over the Soviet Union in land-based ICBM's as of early next year.

—Secretary of State Dean Rusk expressed some doubt as to the wisdom of equipping NATO nations with nuclear-tipped missiles at an early date.

—Russia disclosed the unification of Soviet missile and artillery forces under Chief Artillery Marshal Sergei Varentsov. Until recently, Marshal Kirill S. Moskalenko headed a special rocket command. One report said Moskalenko has been given a lesser post in the unified command.

The new boasts of Soviet missile might came in a number of statements published in celebration of Artillery Day.

Col. Gen. V. F. Tolubko scoffed at recent U.S. reports that Russia has only about 50 operational ICBM's. He called such reports "vain self-delusion."

In another article, Col. Gen. P. N. Kuleshov said the Russians "have successfully solved the problems of destroying various rockets in flight."

However, Kuleshov did not say whether Russia had developed a workable antimissile anti-ICBM system or he merely meant that a Soviet tactical missile is capable of intercepting another tactical missile.

The U.S. Army has already demonstrated several times the capability of various tactical missiles to intercept other tactical missiles. The technical problems involved in ICBM interception are far more difficult.

The Institute for Strategic Studies said a number of reasons have prevented the Russians from deploying a much larger number of ICBM's by now as they originally were expected to do.

One of these is the vulnerability of the big Soviet *T-3's* and the problems associated with base-building. Another complementary reason is that Russia has under development a smaller, better and more easily concealed ICBM powered by a storable liquid propellant.

Shots of the Week

Failures in the Nov. 18 launches of a *Ranger II* spacecraft and a *BIOS* space probe marred an otherwise successful week for U.S. rocketmen.

The *Ranger* spacecraft burned up in the earth's atmosphere after it failed to achieve its planned deep space trajectory. The *BIOS* capsule was lost when it landed far off its planned impact point in the Pacific Ocean.

The Air Force, however, successfully fired a *Minuteman* intercontinental missile from an underground launching tube (see opposite page) Nov. 17.

The Army sent two *Nike-Zeus* antimissile missiles on successful long range tests Nov. 17 and Nov. 21. The launches from the Pacific Missile Range involved the first two stages of the 48-ft., three-stage rocket. For the first time, the missile used a Thiokol second stage.

The Army also chalked up three other successes including: — Two launches of *Nike-Zeus* from the White Sands Missile Range. In the first test, the missile radar tracked a special test target and the ground electronics of the missile defense system successfully controlled a *Zeus* missile in flight. In the second, the missile was fired from an operational-type underground silo, then maneuvered in flight in response to control commands from its ground guidance center.

A U.S. Army *Pershing* missile was also successfully launched from Cape Canaveral.

The *Ranger* shot was beset with the same problem which hit *Ranger I*. The *Agena B* second stage again failed to refire, thus failing to send the spacecraft into a deep space trajectory planned as planned.

The spacecraft separated from the *Agena* and burned up in the earth's atmosphere following its sixth orbit. Officials said the failure might delay the launch of *Ranger III*, which is designed to rough-land on the moon. That shot had been scheduled for early 1962.

The *BIOS II* capsule—designed to determine the effects of the Van Allen radiation belts on living matter —was launched successfully into the Pacific Missile Range. The 85-lb. capsule parachuted into the sea far off course and was lost—as was *BIOS I* on Nov. 15.

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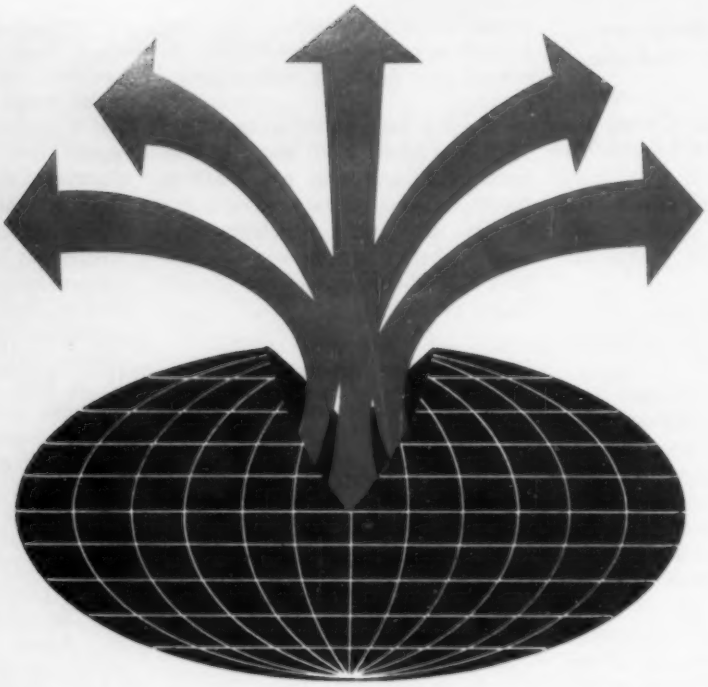

EARTH SCIENCES AT DRESSER ELECTRONICS, NATURALLY!

Since 1945 Dresser Electronics has been solving instrumentation problems associated with earth probes—first to find oil traps for petroleum geophysicists, now also to provide immediate answers to vital defense and security problems. A sample of present contracts—

for: **U.S. GEOLOGICAL SURVEY (Major Crustal Studies Project)**—Long-Range Recording Systems for VELA UNIFORM program.

DEPT. OF DEFENSE (Civil Defense)—an Automatic Radiation Monitoring System.

USAF (ARPA)—development and prototype of Unmanned Seismic Station.

US ARMY (Signal Supply Agency)—instruments and field studies relevant to seismic techniques for Missile Impact Location.

USAF (Systems Command/Hanscom Field)–development of VLF Electronic Seismometer with possible lunar probe application.

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TRAAC Opens Doors

The orbiting of the Navy's *TRAAC* appears to have opened the way for improvement of the nation's surveillance and early warning satellites.

The *TRAAC* satellite—launched into orbit on *Transit IV-B* on Nov. 15—employs the earth's gravitational field for stabilization.

Though the announced application of this new probe was for the Navy's *Transit* navigational satellite program, a more important application is evident. The satellite could become the forerunner for improved stabilization techniques for many of this country's observation-type satellites, including *Tiros, Samos,* and *Midas.*

The Navy's proposed *Yo-Yo* reconnaissance satelloid program might also benefit.

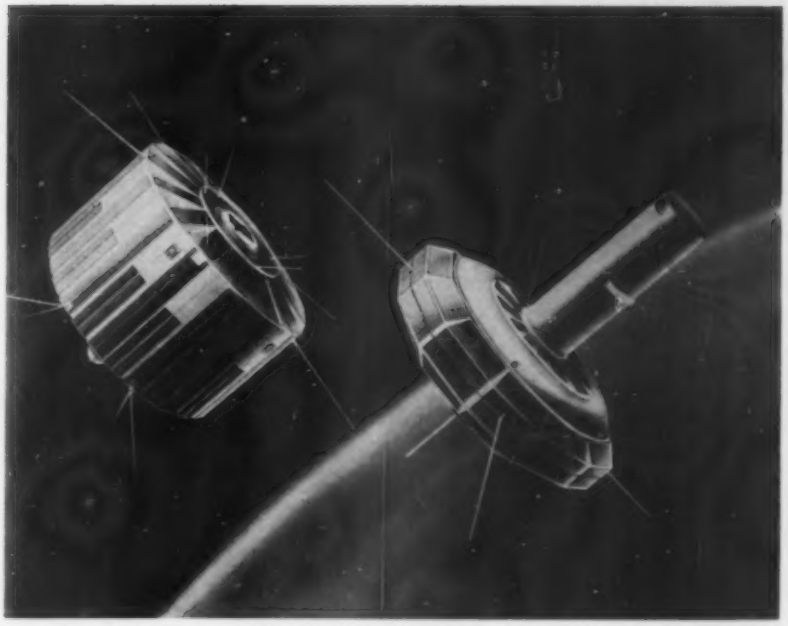
TRAAC, which stands for Transit Research and Attitude Control, was carried into orbit by *Transit IV-B* piggyback fashion. The major advantages of an earth-oriented vehicle for the *Transit* series involve improved transmitted signal reception and reduced power requirements.

Gravitational stabilization in the new system is maintained through purely passive means. This cuts weight requirements considerably over methods employing mechanical sensors and scanners.

The satellite is a door-knob-shaped affair which attains initial north/south stabilization through magnetic devices. Navy and APL scientists figure this initial stabilization takes about eight days.

At this point, a ground signal triggers a device in the satellite which releases a weight and rod arrangement from within the boom housing on the satellite. The shift in weight and mass distribution creates a dumbbell shape for *TRAAC,* with the heavier end moving into a slightly slower orbit and closer to the earth. This, in essence, is the concept which keeps the same surface of the moon facing us. A lightweight spring is attached between both ends of the satellite for damping purposes.

Instrumentation for this gravity-gradient stabilization experiment includes solar and magnetic attitude detectors and spin rate detectors. These devices determine satellite attitude with respect to the sun, the earth's magnetic field, and the earth's gravitational field. Telemetering equipment is also aboard.



SEPARATION of Navy's Transit satellite (left) from piggyback TRAAC satellite took place at 500 mi. altitude Nov. 15 as shown in this artist's conception.

In addition to its primary mission, *TRAAC* is supplying data on particle detection experiments of the inner Van Allen radiation belt.

These experiments include probes to study the number density of protons, search for trapped particles heavier than protons, and investigate the cosmic-ray neutron albedo theory of the belt's origin.

Success of the experiment was in doubt last week due to a malfunction in the command-receiver system.

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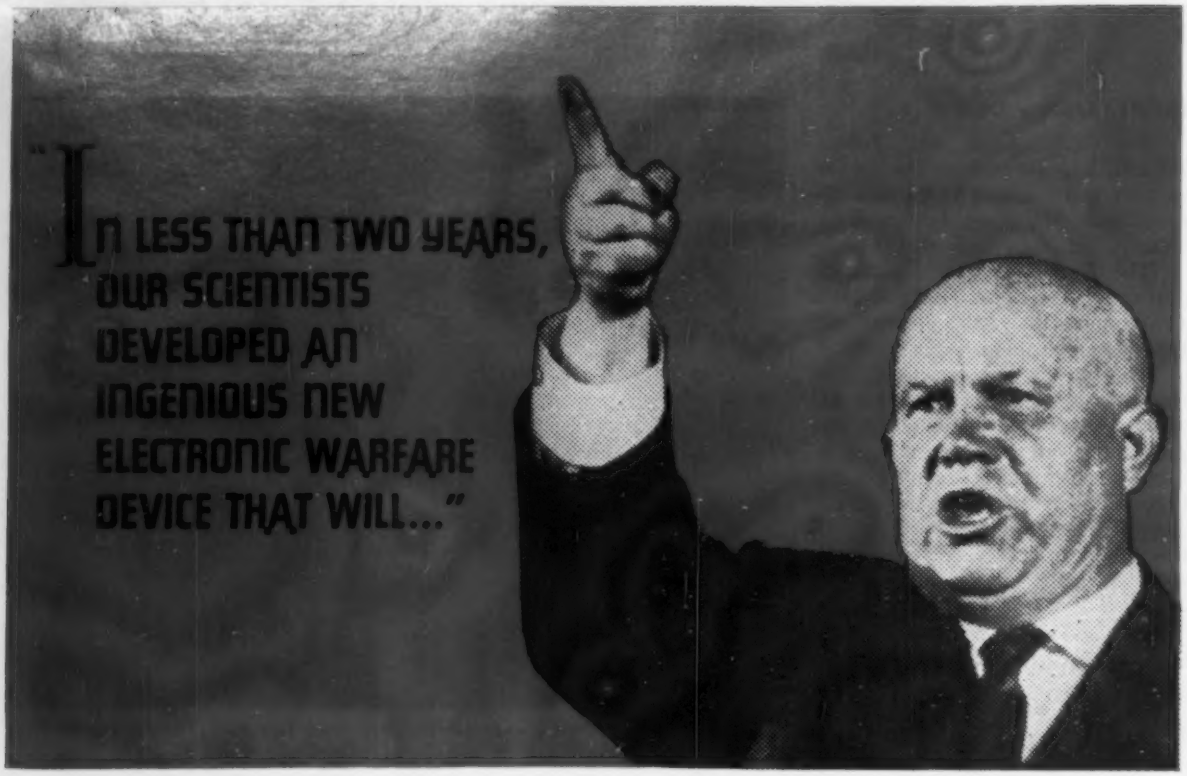

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Tiros II One Year Old

NASA's *Tiros II* meteorological satellite passed a new milestone last week with the completion of its 5354th orbit, ending one year of successful operation.

The space agency said that the satellite has now been in orbit a total of 8760 hours—during which it has transmitted more than 35,000 photographs of the earth's cloud cover and billions of bits of infrared data for measuring the earth's heat balance.

NASA Recruiting Drive

NASA has announced that its personnel recruiting teams will visit nine U.S. cities in late November and December.

The space agency said that the teams—attempting to fill 2000 scientific and engineering positions—will spend about three days in each of the cities in the eastern and western sections of the nation.

The western schedule includes Los Angeles, Nov. 27; San Diego, Dec. 1; San Francisco, Dec. 5; and Seattle, Dec. 9.

The eastern team will visit Cincinnati, Nov. 27; Pittsburgh, Dec. 1; Philadelphia, Dec. 7; Washington, Dec. 12; and Baltimore, December 15.

Douglas Plans Expansion

The Missile and Space Systems Division of Douglas Aircraft Co. is studying plans for plant and research expansion which may total $50 million over the next 10 years.

Charles R. Able, division vice president and general manager, said that the plans cover requirements for engineering, administrative, test and laboratory, basic research, and manufacturing facilities through 1971.

Construction of a $3-million space chamber will begin in the near future.

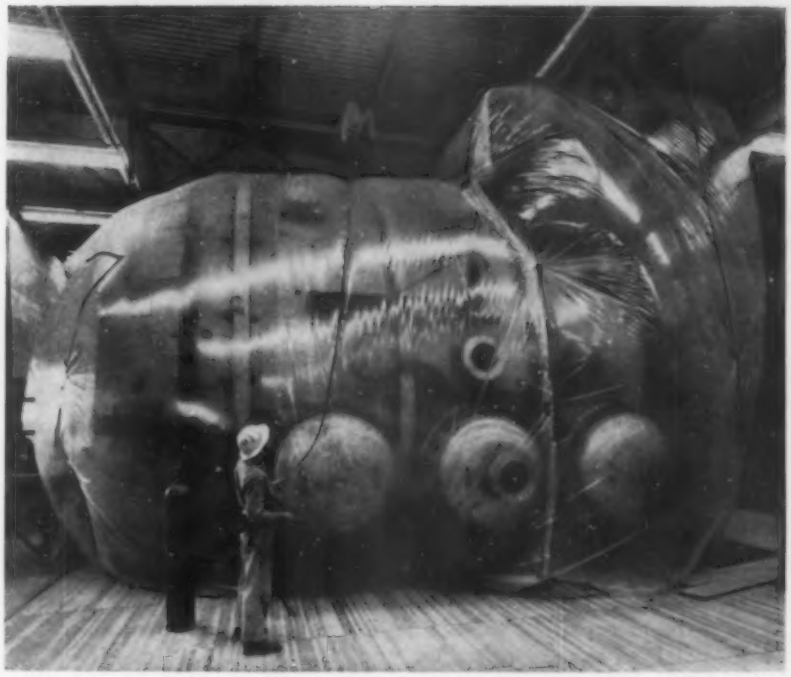
Able estimated that manpower needs of the Division—located in Santa Monica, Calif.—will grow from the present 17,000 persons to 25,000 by 1971.

Radioisotopic Capsule Tests

Effects of extremely high temperatures on radioisotopic fuel capsules designed to provide power for space vehicles will be tested next month by the Air Force Special Weapons Center.

Four tests, with General Dynamics/Astronautics participating, will be held at the Atomic Energy Commission's Nevada Test Site.

They will provide data on the capability of radioisotopic fuel cap-



Plastic-Wrapped Space Simulator

BENDIX CORP'S environmental chamber, seen here undergoing final checkout, will be used to test full-sized satellites and space capsules. The 20 by 27 ft. unit is part of a new Bendix $10 million space lab at Ann Arbor, Mich.

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sules to remain intact when exposed to fire, and will permit study of the behavior of nuclear material which might be released into the atmosphere in the event a capsule melts.

Limited Nike-Zeus Production Considered by Administration

The Kennedy Administration is considering a revised plan to include a limited production program for *Nike-Zeus* in the FY '63 defense budget.

The program would enable the Army to begin production work on the big Western Electric antimissile missile next summer if it is proved out in the coming final tests earlier in the year.

Some sources report that Defense Secretary Robert S. McNamara has already approved inclusion of the program in the budget and that only White House approval is now needed.

The program would enable the Army to begin deploying about 12 batteries of *Zeus* missiles toward the end of 1965. The batteries would be located around the country to defend a number of key metropolitan areas. Full *Zeus* batteries are expected to have 20 to 30 missiles.

The initial outlay for production in the FY '63 budget is expected to be about $150 million to $200 million. The budget also will include about $200 million for continued R&D. Total cost of the limited production program would run well over $1 billion. Total cost of the full program previously proposed by the Army would be about $8 billion.

The limited program—an expansion of the one proposed last year by the Army—would be designed so that it could be greatly stepped up. The Administration, by waiting to put the money in the FY '63 budget, also would leave itself the option to kill production before it even started.

High-Temperature Resonators By Electrolysis of Quartz

Treated quartz resonators for use in high-temperature environments are now possible through a Bell Telephone Lab development in quartz electrolysis. The process sweeps out impurities and the quartz retains its ability to vibrate with little energy dissipation even when used at 550°C. Depending on the angle of cut, processed quartz exhibits turn-over points at temperature from 300° to 535°C. At these high temperatures there is a constant annealing out of ionization effects which makes the crystals ideal for applications in the Van Allen Belts.

Nuclear Work Shifts to Lewis

NASA is consolidating its nuclear electric propulsion program at the Lewis Research Center in Cleveland.

As a result, current research work in this area at the Marshall Space Flight Center will be transferred to Lewis.

The transfer, however, will not affect the *RIFT* program, which will flight-test nuclear rockets as upper stages of large chemical boosters.

That program will remain at Marshall under the direction of Dr. Ernst Stuhlinger, director of the Research Products Division.

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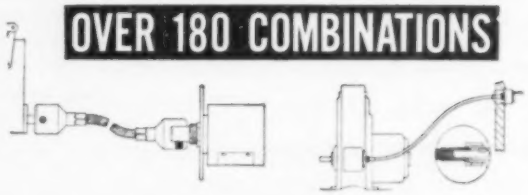

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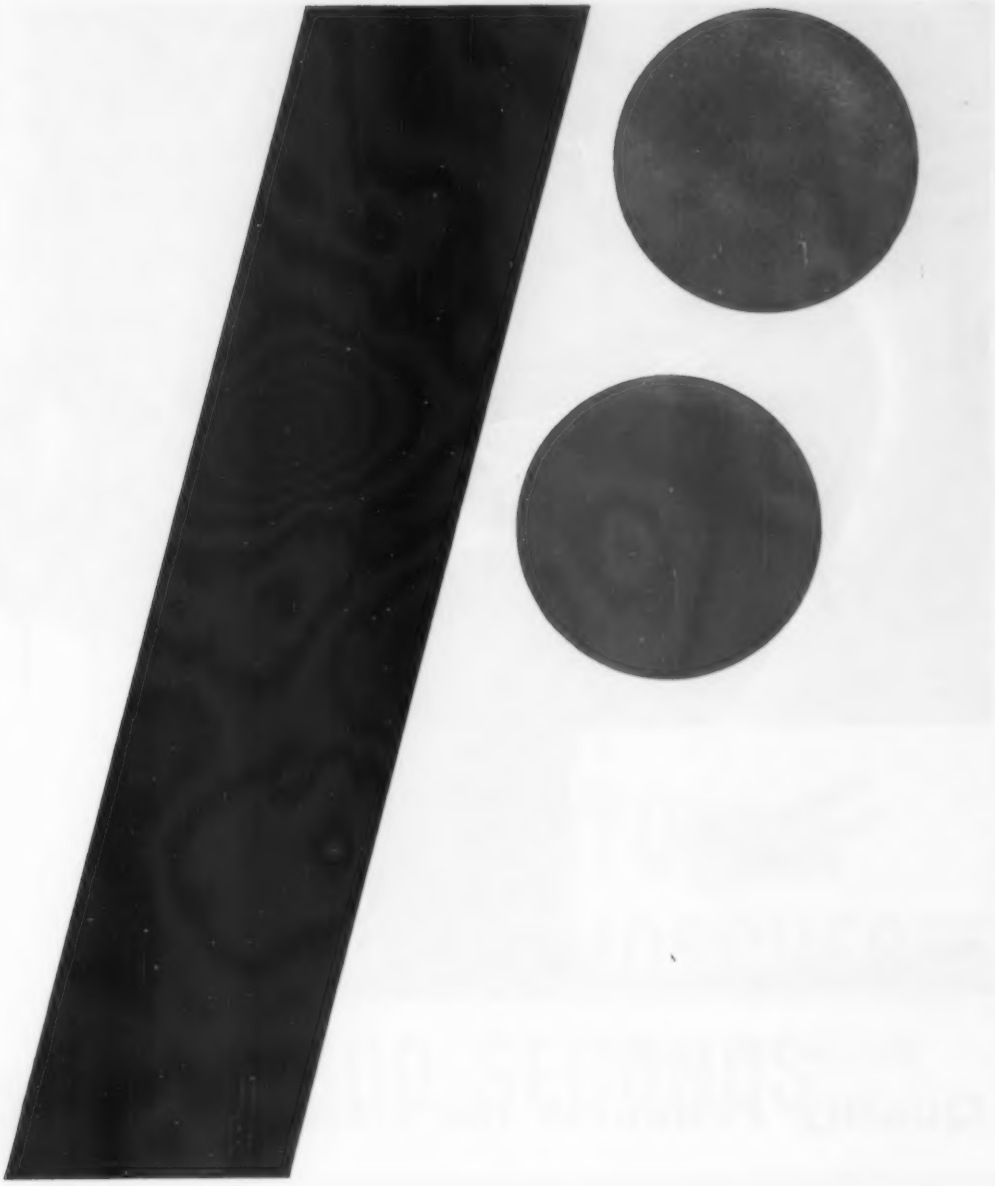

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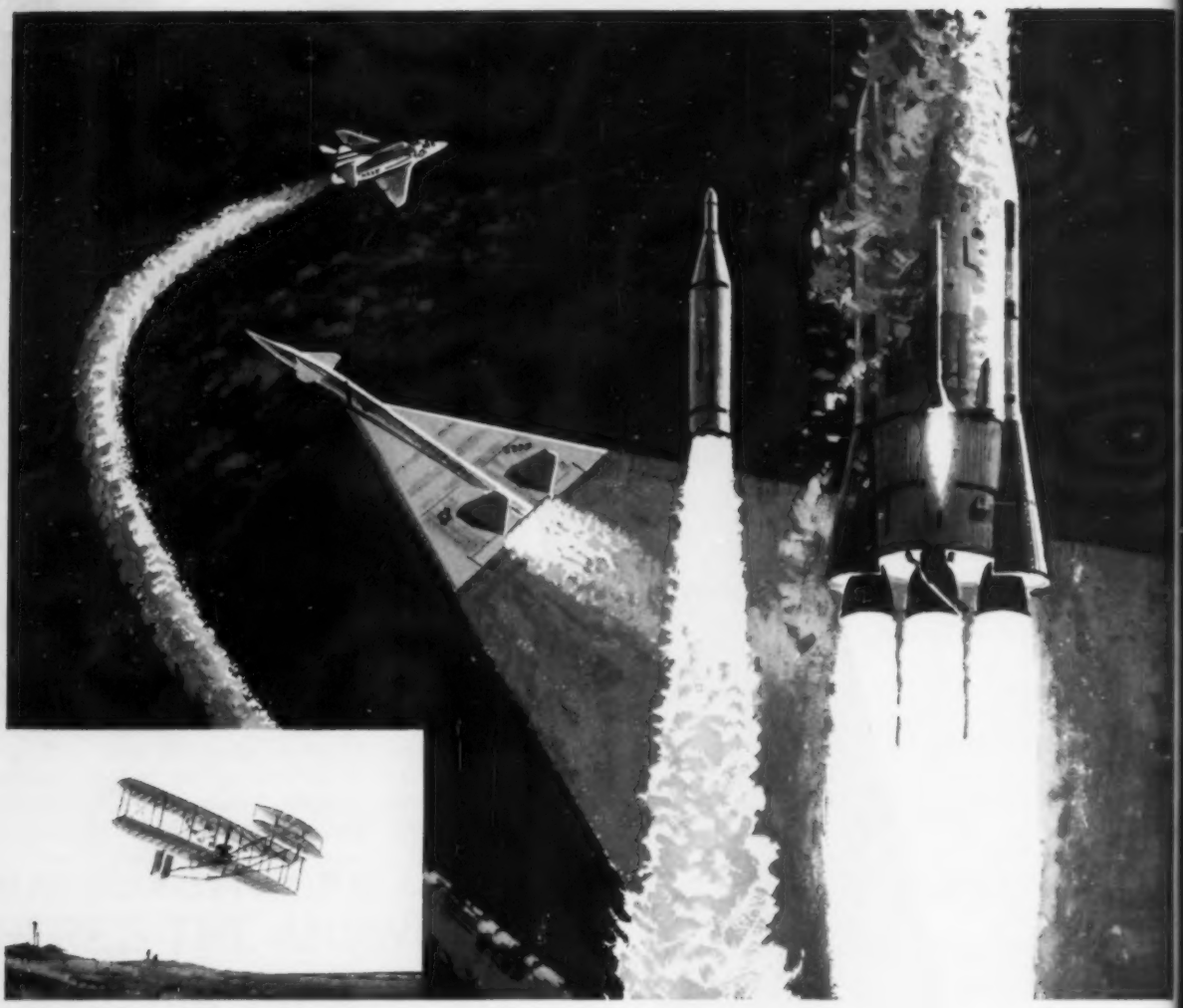

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Training Equipment ■ Flight and tactics trainers, simulators for military weapons systems and all types of military and commercial aircraft; radar simulators, radar maintenance trainers and aircraft engine trainers. Special purpose analog/-digital computers.

Electronic Components ■ Relays, delay lines, solenoids, connectors, stepping motors, counters, digital modules, timers.

Electronic Instruments ■ Peak reading voltmeters, transistor test equipment, photographic programmers and intervalometers.

Ground Support Equipment ■ Automatic checkout and related ground support equipment for missiles and aircraft.

Wipers ■ Windshield wipers for military and commercial aircraft.

Metal Products ■ Extruded missile rails, precision forgings, steel castings, and custom extrusions for aerospace applications. Aircraft and stationary turbine engine blades.

Special Radar ■ X-band and C-band radar.

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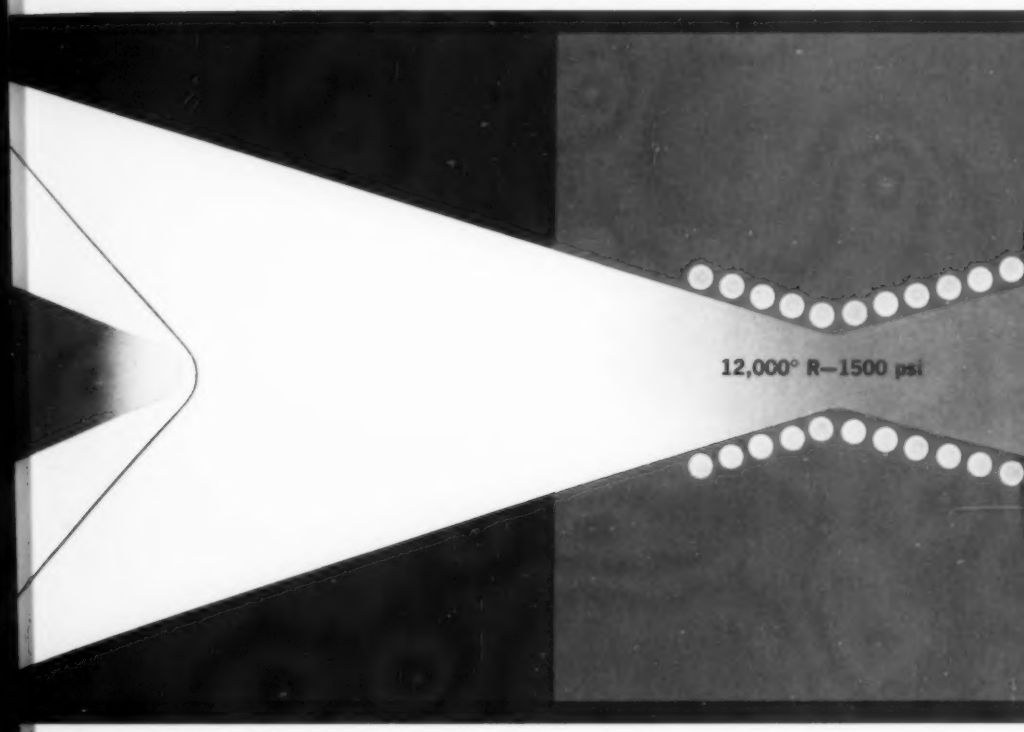

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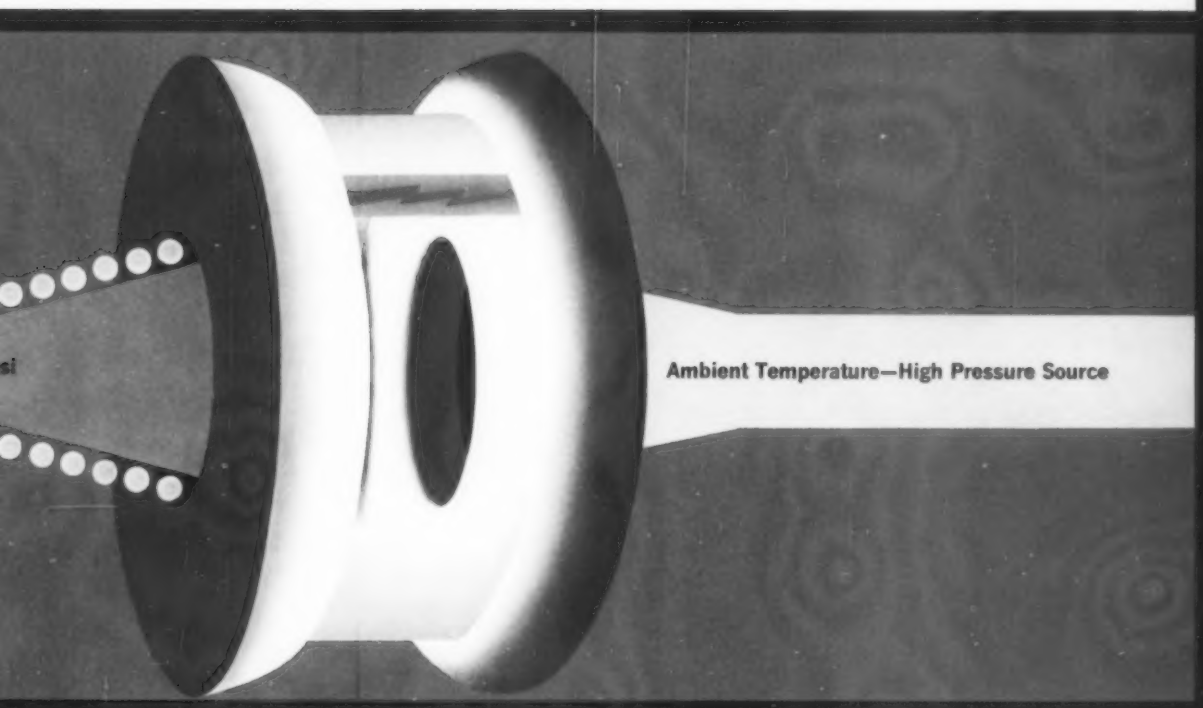

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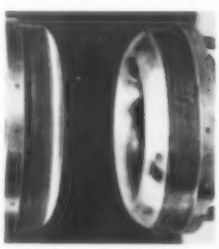

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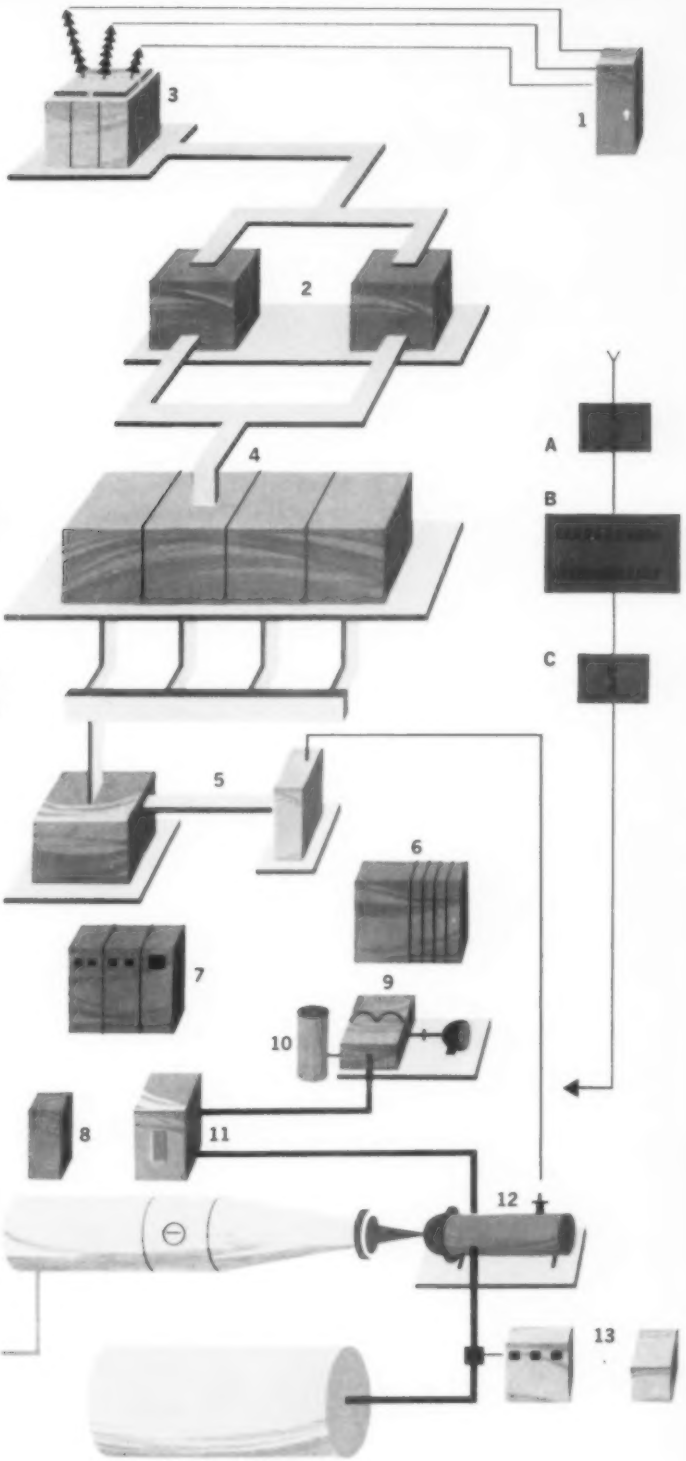

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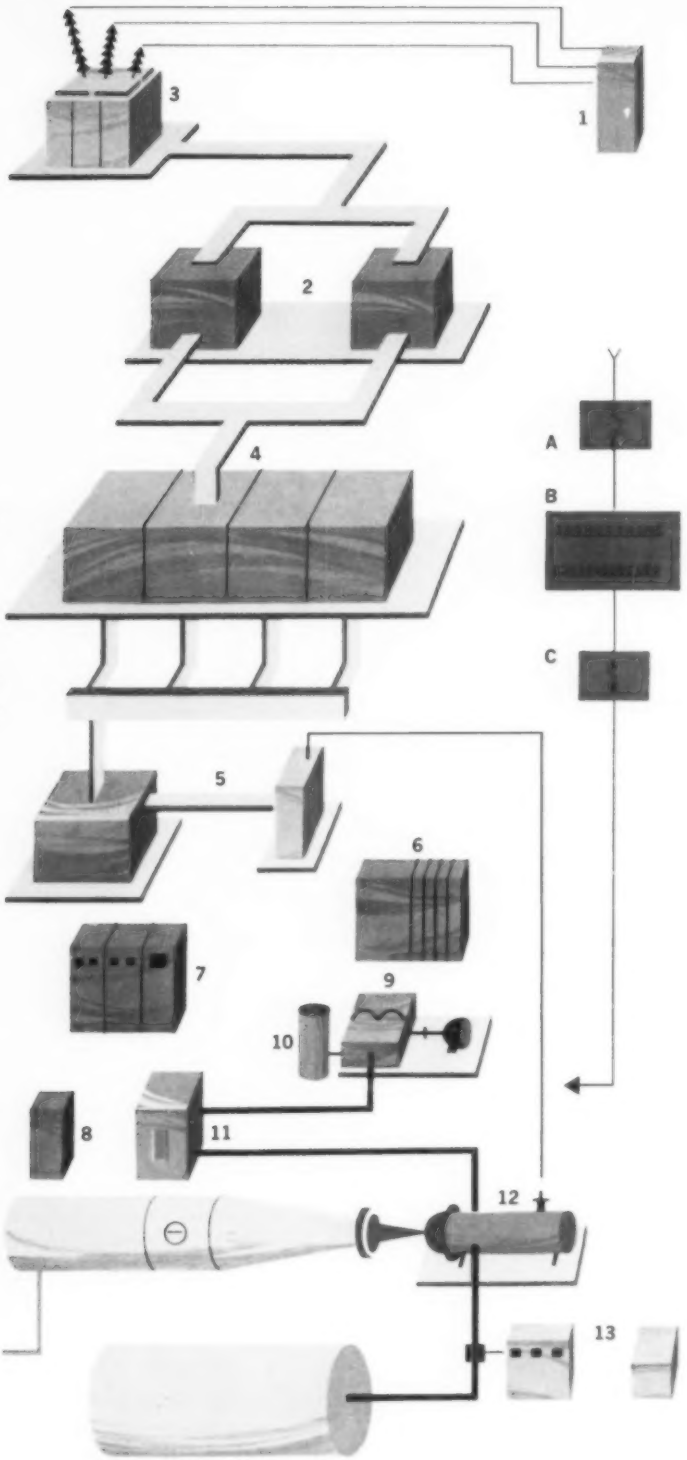
Westinghouse

A typical DC system utilizes modular silicon rectifiers **(4)** fed from balanced power transformers **(3)** varied by the load tap-changer **(2)**. Switching and isolation of the system is done with the metalclad breaker **(1)**. Ballast **(5)**, consisting of matched reactor and resistor stabilizes the arc. Safe, precise, accurate control stations **(6) (7) (8) (13)** provide automatic sequencing with manual over-ride. Trouble-free, long-life operation of the Arc Heater and nozzle **(12)** is insured by the closed-loop cooling system **(9) (10) (11)**.

Increased efficiency and lower initial cost for power is apparent when a three phase AC arrangement **(A) (B) (C)**, is substituted for **(1) (2) (3) (4) (5)**.

Westinghouse system concept assures compatibility of arc heater with expertly selected power components.



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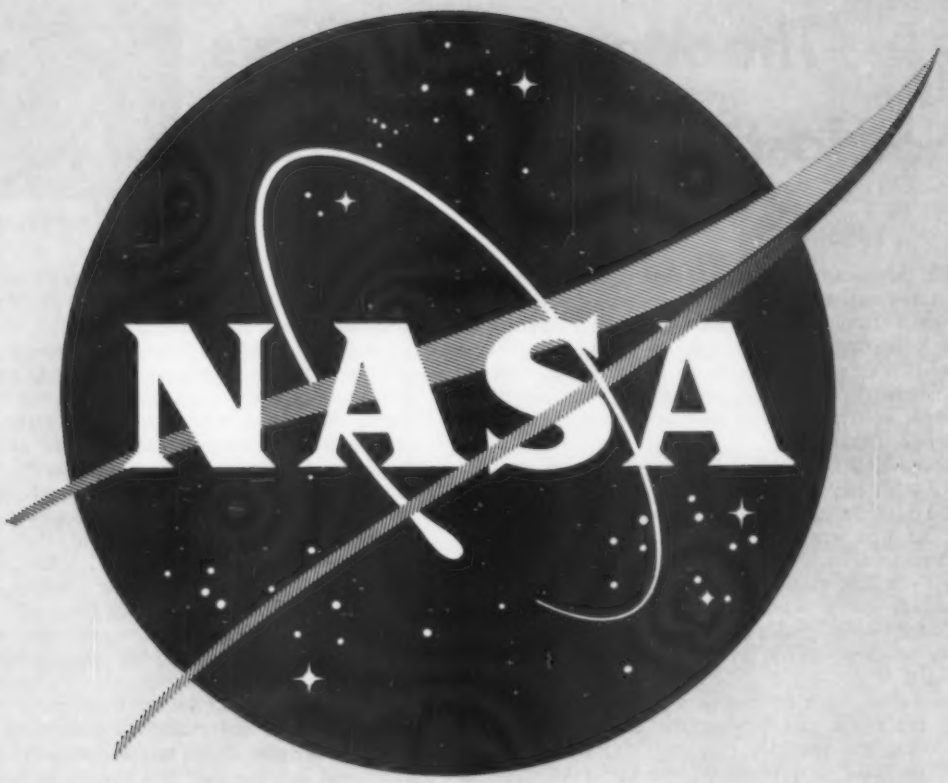
Missiles and Rockets Volume 9, Number 22 Nov. 27, 1961



Mobilizing for the Moon—NASA's Big Plan

AFTER MONTHS of deliberation the plan of attack is ready: How the National Aeronautics and Space Administration intends to mobilize the Missile/Space Industry for manned exploration of the moon. Here, in its premier annual NASA issue, M/R presents the first truly comprehensive report on how the mobilization plan is to be executed. Beginning on page 46, you will find an industry guide to all the key programs and critical hurdles involved in the multibillion-dollar undertaking. Further on there are reports on contracting and each one of the 13 NASA installations across the nation—how they are organized and the important roles they will play in the total space program over the next eight years.

NASA

The Moon: America's Most Difficult Endeavor

NASA Administrator Webb

BEFORE this decade is out, the United States plans to land a scientist-astronaut team on the moon.

The lunar landing, a national goal recommended by President Kennedy and endorsed by Congress this year, is the most difficult and dramatic of the missions assigned to the National Aeronautics and Space Administration. Some people believe it is the most ambitious endeavor in the history of mankind.

• **Other objectives**—NASA has accelerated its program to achieve other important national goals in space:

—Establishment of a global system of communication satellites, so that greatly expanded telephone, telegraph, data communication channels, and — eventually — ocean-spanning TV will be available to our country and the world.

—Creation of a worldwide operational network of weather satellites, to enable meteorologists to observe and predict the weather—and to make a start in the direction of controlling it.

—Broad-scale, rapid advancement of scientific knowledge of space, the moon and planets, the earth's atmosphere, and the fields and particles that surround it, as well as aerospace medicine to provide for the safety of the men who will travel through the solar system.

—Rapid improvement in space technology, including application of nuclear energy to propulsion and generation of electrical power.

—Prompt feedback of space technology into our economy, to make certain of maximum benefits to the American people through economic growth and industrial progress.

• **Motivation**—There are many practical, technological, and scientific reasons why the United States is exerting great efforts toward accomplishing the Nation's goals in space. Perhaps I need not list them for readers of MISSILES AND ROCKETS. Still, I believe that some of the basic considerations that motivated the Nation's decision bear restating.

First, by achieving a pre-eminent position in space, we insure that the over-all technology which the Russians derive from exploring the universe will not be used against us. If we should allow them to surpass us, they would use their superiority to apply heavy pressure on us and the other nations of the Free World.

Second, the stimulus and the knowledge that are developing as we carry forward our broad programs in space will return practical dividends in the form of new products and techniques of great value to industry, the professions, and everyday life.

Third, exploring space is of immense scientific importance. The moon, for example, may hold the answers to such questions as how the solar system was created, where life began, and how planets develop and change. It is, as always, impossible to predict what use will be made of the scientific knowledge. But history has repeatedly shown that the results of investigations in basic science are used eventually for man's betterment.

• **National scope**—No single organization has all the resources and skills necessary for attaining our goals in space. The space program is, and must continue to be, national in scope. Therefore, NASA cooperates with, and depends on, many other Government agencies—the Department of Defense, the Atomic Energy Commission, the Weather Bureau, the Federal Communications Commission, the Federal Aviation Agency, the National Science Foundation, the National Academy of Sciences, and others.

To assure maximum progress, NASA utilizes industrial contractors to the greatest extent possible. Eighty cents of every dollar NASA spends goes for contracts with industry and private organizations, for materials, supplies, salaries, research, development, and for other services.

In order to supervise contractors' work effectively, we must understand and follow it in every phase from start to completion. This requires a competent NASA in-house staff. As the size of the task assigned to contractors grows, additional in-house staff will have to be added to efficiently manage the program.

• **Self-sacrifice**—Some of the Nation's best qualified men in aerospace science and technology, men who have made important contributions to the national position by their work in our universities and industry, have accepted leading roles with NASA. They bring into the effort the highest personal, professional, and managerial qualifications. These men, and many others associated with them, have demonstrated personal earning capacities far beyond what the Government is able to pay for their services.

It is fortunate for this Nation that men with such high qualifications and experience are willing to forego large earnings and normal personal and family life to supply the leadership needed in our national space effort.

• **'Prompt decisions'**—The past months have been a time of many decisions in the U.S. space program. I need not recount for the readers of MISSILES AND ROCKETS the actions by the President and Congress, the selection of sites for launching and testing large rockets and spacecraft that will be required, the enhancement of existing programs, the awarding of major contracts, and the reorganization of NASA that have taken place.

By making decisions promptly, we have been able to get moving at high speed toward the accomplishment of our national goals in space. We will continue to make prompt decisions.

James E. Webb

Deputy Administrator Dryden

Industry's Toughest Assignment: Make it Work

A PROGRAM designed to land a man on the moon and bring him back safely in this decade is perhaps the most difficult single task that this nation has ever undertaken.

It will require personnel and facilities of not one, but several government agencies—including the Defense Department, the Atomic Energy Commission, the Department of Commerce and the National Aeronautics and Space Administration.

College and university laboratories will be called upon to support basic research activity and supply the country with increasing numbers of qualified scientists and engineers.

Industry will design and fabricate the boosters, space vehicles, launch faciiities and worldwide tracking stations for the many different types of space missions. Industrial management and scientific teams will be asked to furnish the know-how that is required to solve the multitude of problems facing us in the space age.

• **Prime requirements**—The most immediate problem is the development of reliable launch vehicles and spacecraft capable of performing sustained manned space flight missions.

Beyond this a life support system to provide a suitable environment for periods of several weeks is required. Radiation shielding is needed to give sufficient protection during passage to and from the moon as well as on the lunar surface.

Another requirement is a navigation system which will give position fixes, and which will compute the amount and direction of thrust for course corrections when required. An attitude stabilization system to be used throughout the flight is also needed to permit orientation of the spacecraft for thrust control as well as for lunar landing and reentry through the atmosphere. And of course communications will be required for all phases of the flight.

• **Industry's duty** — In meeting the problems directly connected with the Nation's accelerated space program, industry must also assume special responsibilities. One of the most important is to strive for reliability of all parts of a complex system no matter how small or seemingly unimportant. Failure of one small part can mean complete failure of an important and costly mission. Another important industry responsibility is to work with universities in order to provide for the education of greatly increased numbers of scientists, engineers and technicians for roles in space exploration, and for other major technological developments of future importance to this country.

The space age challenge to industry, however, is not only to mobilize its forces for a direct attack on the problems involved in manned space flight, but to look for and develop the new consumer goods and industrial processes that are certain to evolve from this program for the benefit of all mankind.

• **The bigger dividends**—History abounds with examples of the manner in which man's striving toward difficult technical goals has brought on vast, unforeseeable dividends.

Development of the automobile, for example, brought us the concept of simplification for the operator through complication of design, a concept now widely applied in the operation of a modern steel mill or oil refinery and in such modern consumer products as automatic washers and ovens, where automatic controls program the entire operation. The automobile is largely responsible for the development of alloy steels, new fuels, synthetic rubber, quick-drying finishes, and other new materials.

Similarly the air age brought about the use of aluminum for building lightweight structures, not only for airplanes but for trains, buses and ships. The nuclear age brought applications of isotopes in medicine and in the inspection of materials. Nuclear developments brought remote manipulators and sealed pumps for hazardous liquids and gases.

The forward movement of space technology, with its many ramifications in our industrial life, will stimulate our economy just as these other great technological developments have done in the past.

A multitude of space-related products have been developed in the United States. Miniature electronic parts devised to save weight in rockets and their payloads are now being used in tiny hearing aids, medical equipment, midget radios and portable TV sets, and in a host of other products.

Into other consumer goods are going new materials, alloys, plastics, fabrics, and compounds of many kinds originally created to do space jobs. In fact, the space program is drawing upon and stimulating virtually the entire industrial spectrum—electronics, metals, fuels, ceramics, machinery, instruments, and textiles.

There is great potential in communications satellites, meteorological satellites and navigation satellites, all under development.

While the technological developments offer the earliest contributions to the economic development, in the long run the contributions from the scientific knowledge obtained in the great unknown environment of interplanetary space may bring much greater returns, perhaps far beyond what man at this time could possibly envision.

Hugh L. Dryden

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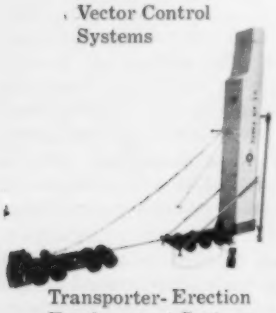

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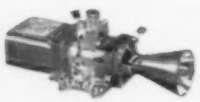
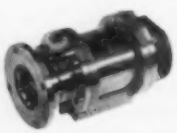


Attitude Thrust Controllers – Space Vehicle



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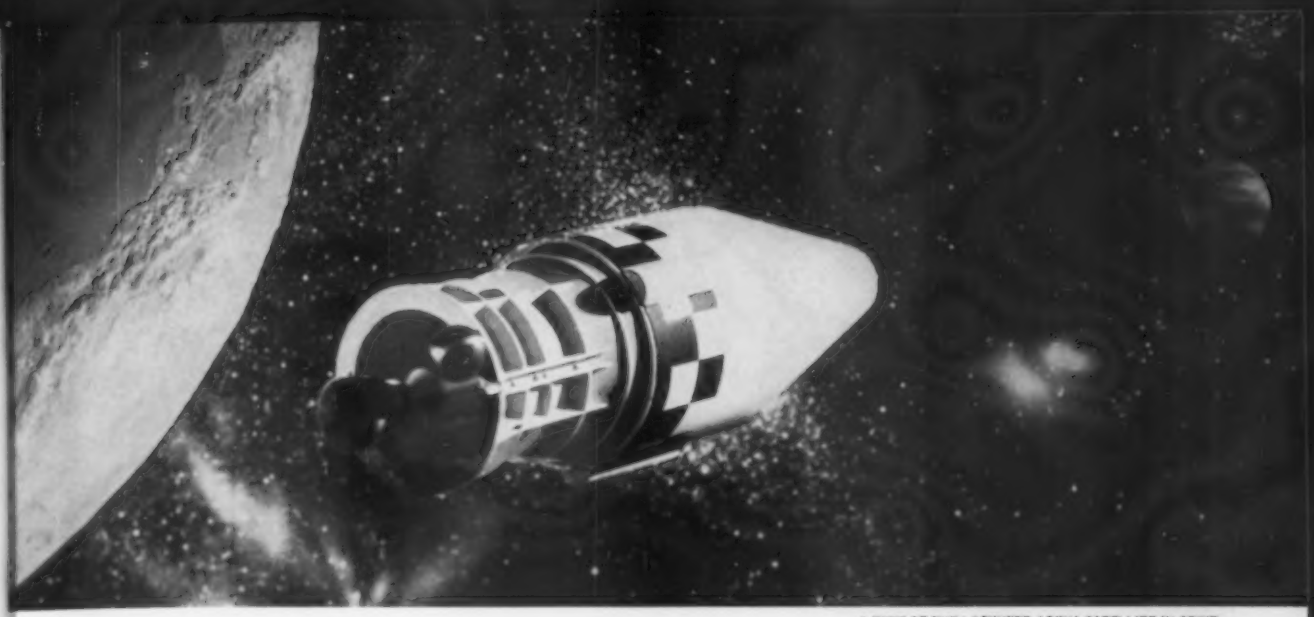

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The $50-Billion Space Push

Some 70 percent of NASA's budget flooding into Apollo Manned Lunar Landing Program; agency fixes government-industry team and readies basic contracts

BIG MONEY is about to flood into the NASA-led drive for the moon.

The basic contracts are nearly ready to be let for the *Apollo* Manned Lunar Landing Program—a rapidly escalating assault on space that is now expected to push NASA's total spending in this decade to more than $50 billion.

For some six months the vastly accelerated U.S. drive to beat Russia in landing the first men on the moon has consisted primarily of study and planning. That period is ending.

The overall plan now calls for orbiting the first *Apollo* spacecraft around the earth about 1964 and landing the first Americans on the moon about 1967. The previously planned circumlunar flight before attempting a landing may be dropped. The framework of the government-industrial team for this staggering undertaking is all but fixed.

Within the next four to eight weeks NASA will award a tattoo of key prime contracts that eventually will run into billions of dollars.

In doing this, NASA will pick the leaders of the *Apollo* industry team. And, for the first time, it will have put the entire program in motion.

About This Special Issue . . .

This issue, devoted entirely to the work and plans of the National Aeronautics and Space Administration, was researched and written by a Missiles and Rockets editorial task force which visited every NASA installation across the nation. Headed up by NASA Editor Hal Taylor, the task force consisted of Senior Editors James Baar and Charles D. LaFond, Engineering Editor William Beller, Materials Editor John F. Judge, GSE Editor James Trainor, Space Medicine Editor Heather M. David and, on the West Coast, M/R Editors Richard van Osten and Bill Wilks.

• **Scramble for top**—There are a total of 17 missile/space companies fighting for top position on one or more of the major contracts.

Two—General Dynamics/Astronautics and Martin—are seeking the prime contract in both propulsion and spacecraft systems. Three others—Lockheed, Ling-Temco-Vought and Space Technology Laboratories—are bidding for one part of the program as primes, and as associate primes for another.

The three key contracts are:

—Production of the *S-1* booster—Seven firms are competing for the contract on the clustered 1.5-million-lb.-thrust first stage of the *Saturn C-1*. The seven are Boeing, Chrysler, Ling-Temco-Vought, Ford Aeronutronic, Avco, Northrop and Lockheed. The contract is expected to be let imminently.

—Production of the *S-1B* booster—Five firms are competing for the contract on the expected cluster of four 1.5-million-lb.-thrust F-1 engines for the *Saturn C-4* booster. The five are Boeing, Martin, Aerojet-General, Space Technology Laboratories, and General Dynamics/Astronautics. The contract is expected to be let early next year.

—Development of the *Apollo* spacecraft—Five firms are competing. They are Martin, General Dynamics/Astronautics, GE, McDonnell and North American Aviation. GE has a bidding team including Space Technology Laboratories, Douglas and Grumman. McDonnell has a team including Ling-Temco-Vought, Lockheed and Hughes. The contract is expected before Jan. 1.

Meantime, the first contracts in the lunar facilities construction program at Cape Canaveral are also expected to be let early next year. Latest estimates on the total cost of the huge new spaceport are running to more than $1 billion.

NASA officials have already decided that the R&D program for the *Apollo* spacecraft will be handled by a prime contractor and a number of associate primes. However, a decision on the organization of the industry team for the overall *Saturn* vehicles is still pending.

NASA is considering three possible ways to put together the *Saturns*. The prime contractor for the booster could be made the overall prime as well. NASA's Marshall Space Flight Center, which is in charge of the *Apollo* superbooster program, could do the integration. Or Marshall could do it with technical assistance from a contractor.

The establishing and refining of plans for the *Apollo* Program have been accompanied by refining of cost estimates. The trend is upward.

Originally, some official estimates put the total cost at about $20 billion. Some estimates now put the cost at about $35 billion or more depending on what is included.

Like the estimates of all big R&D programs, the figures for *Apollo* and other NASA programs become increasingly tentative as they stretch toward the end of the decade. As a guide, however, $35 billion plus may be considered reasonable—and probably low.

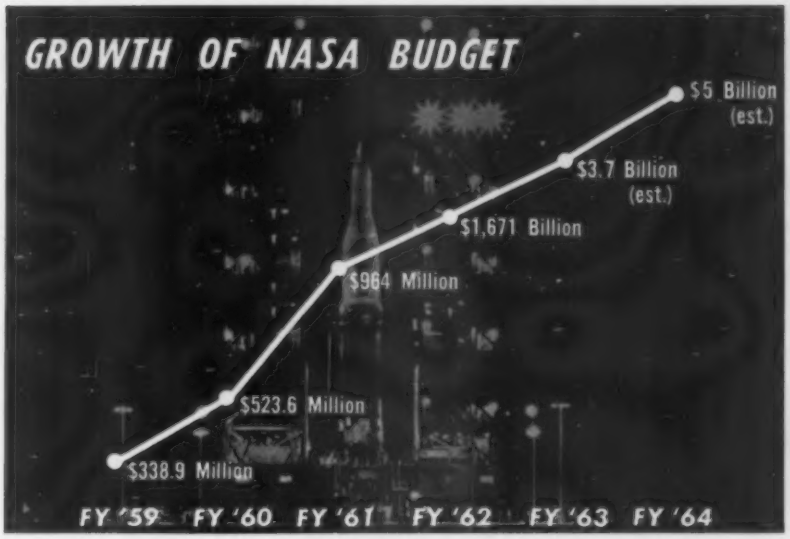
The hardest figures are the expected budget requests for the next two fiscal years. For FY '63, NASA is seeking a total budget of about $3.7 billion—more than double the $1.7 billion that Congress authorized for the current fiscal year. NASA also is seeking a supplemental FY '62 appropriation, probably some $112 million to make up the amount cut by Congress last summer.

For FY '64, NASA is expected to seek about $5 billion to $5.5 billion. That is nearly half of the current budget of the U.S. Army; more than the annual outlay for the Strategic Air Command.

This FY '64 figure of about $5.5 billion is officially looked upon as an annual "plateau figure" for the rest of the decade. By adding normal price increases and the usual unforeseen costs, the "plateau figure" will push total NASA spending for the 1960's to about $50 billion.

One of the important variables in reaching this estimate is the cost of manned spacecraft programs beyond the first three-man missions to the moon.

NASA Administrator James Webb has already spoken of begin-



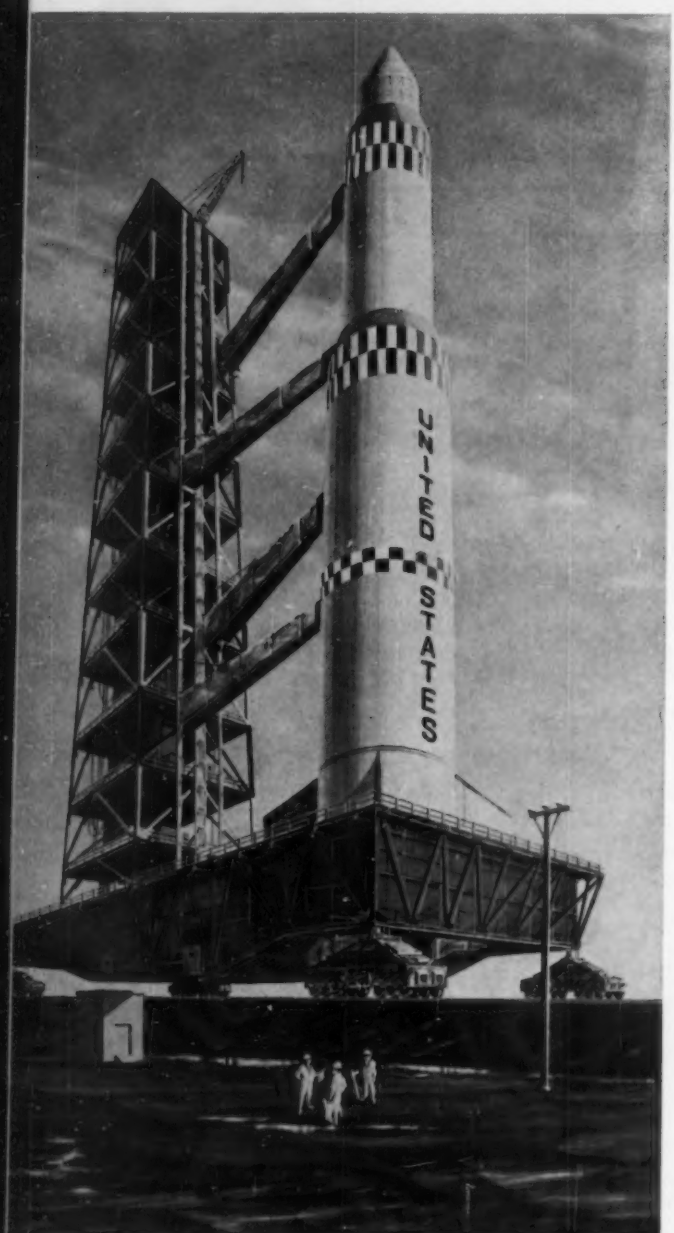
NASA's R&D (right) falls into three groups: top (blue), Apollo Manned Lunar Landing; (bottom gray) applied & scientific; (middle white) work contributing to Apollo and other programs.

Program	FY '60	FY '61	FY '62
	(Authorizations in Millions)		
Apollo	$ .1	$ 1	$ 160
Mercury	84.3	109.5	74.2
Launch Vehicle Technology	—	9.1	27
Launch Operations Development	.1		1.5
Spacecraft Technology	4	7.9	10.3
Solid Propulsion	1.7	1.3	3.1
Liquid Propulsion	27.2	57	93
Nuclear Systems	5.6	12.6	36
Space Power Technology	3.5	4.2	5.5
Saturn	9.4	118	224.1
Tracking & Data Acquisition	16.1	31.6	38.6
Nova	—	—	48.5
Life Sciences	—	5	20.6
Lunar and Planetary Exploration	49.9	82.5	159.9
Centaur	9.4	118	224.2
NASA Plant Support	27.7	48.2	89.1
Research Grants & Contracts	4.8	5	7.6
Scientific Satellites	20.2	37.9	72.7
Electric Propulsion	1.3	3.3	6.8
Meteorological Satellites	7.9	18.1	50.2
Communications Satellites	3	29.5	94.6
Sounding Rockets	9.7	8.2	9
Scout	3	3.9	3.7
Delta	12.5	11.8	2.9
Vega	4	(Program Killed)	
Total R&D	333.1	668.5	1,295.5
Total Salaries and Expenses	89.4	176.9	230.1
Total Construction	99.6	124.7	262
GRAND TOTAL	$523.5	$964	$1,784.3

ning work in the mid-60's on a 10-man or 12-man space station for use in "further lunar and interplanetary exploration." And funding will be included in the budgets for FY '63 and FY '64 for planning and early design work on advanced spacecraft of various types.

A second important variable is the role of the Air Force in space. Sizable increases in military space programs over the next few years could result in the revision of NASA long-range plans with a complementary revision in the agency's budget.

However, this would not necessarily result in a budget reduction. It would depend on whether NASA or the Defense Department undertook the funding of future development programs needed for both space exploration and space weapon systems.



NASA ARTIST'S CONCEPT of rail-transportable launch for Saturn C-4. Alternative would be barge launching.

The Air Force also has advanced the argument that its facilities and trained personnel should be brought into the Manned Lunar Landing Program as much as possible. Conceivably, use of these resources could result in some downward revisions of NASA spending. However, there is considerable disagreement as to the availability and applicability of Air Force facilities and personnel. At least one congressional investigation in this area is planned for early next year.

A principal target for congressional inquiries in this line is NASA's plan to establish a new multimillion-dollar headquarters for its Space Task Group at Houston, Texas. Both the need for all or part of the planned Houston facilities and the site are being questioned.

NASA officials contend that the Space Task Group which is in charge of development of the *Apollo* spacecraft has needed expanded facilities for some time. They contend that, among other reasons, Houston was chosen as part of a deliberate program to broaden the nation's technological base.

A third important variable in the size of NASA's future budgets is political support in the Administration and Congress. At present, vast increases in spending on space programs are enjoying wide political backing. The cut-off within the national budget has yet to be reached.

• **Strength in union**—An important factor in maintaining political support is certain to be the continued invoking of the argument that *Apollo* is necessary for the future security of the nation. The NASA and DOD space budgets along with the smaller space budgets of other agencies are expected to be lumped together in a special section of the National Budget that will be sent to Congress in January. This technique could have its political advantages as well as drawbacks.

Disentangling NASA budgets to determine how much is being spent on the *Apollo* Program and how much on other programs is difficult because of considerable overlapping in a number of areas.

Such unmanned spacecraft as lunar-exploring *Prospectors* and *Surveyors* will greatly expand mankind's knowledge of the moon and therefore have a substantial scientific value in their own right. But they also will greatly aid manned exploration of the moon at a later date.

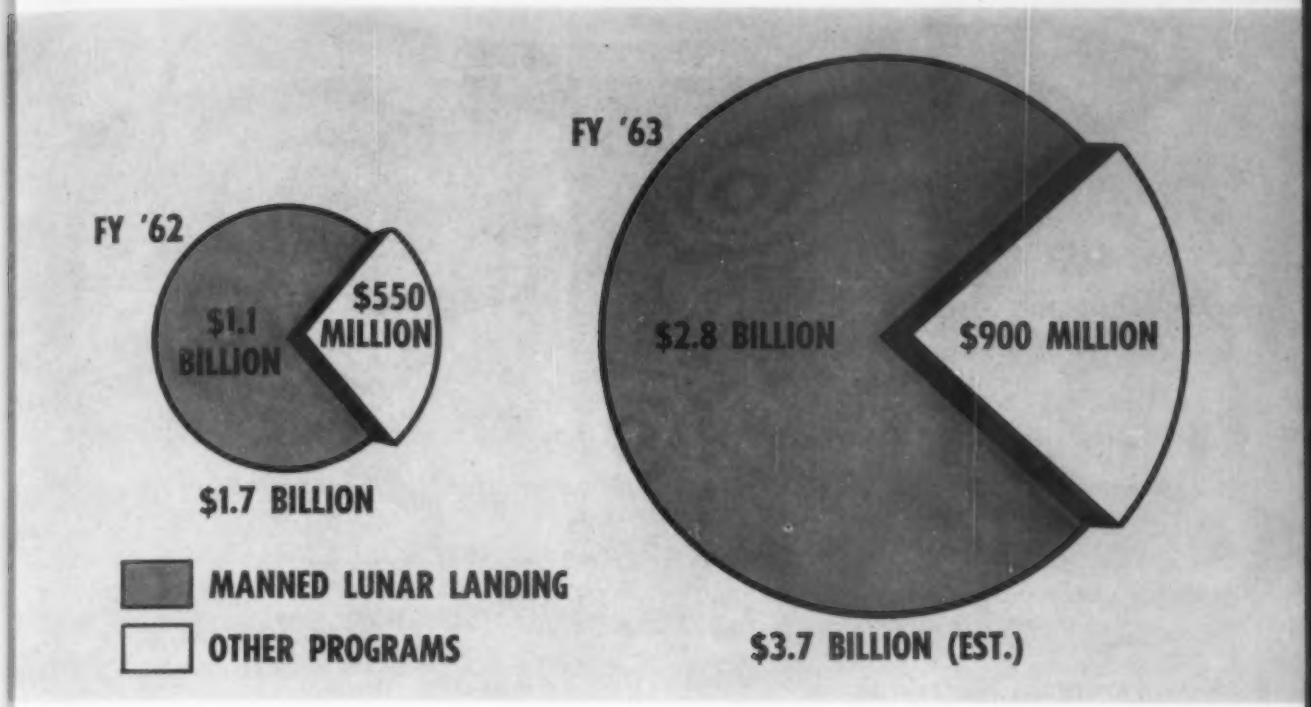
Additions to the NASA tracking network are needed for unmanned exploration of space. However, the bulk of the additions would be needed for manned spaceflight and manned lunar landings even if there were no other programs.

Other gray areas include the programs for scientific satellites, the *Centaur* upper-stage and basic research performed under grants and contracts. And, finally, money for support of the NASA plant, salaries and expenses and construction of facilities is often difficult to attribute to one program or another.

In NASA itself, budget officials attribute roughly 60 percent of the agency's current $1.7-billion budget to the *Apollo* Lunar Landing Program and 40 percent to all other programs.

Moreover, they expect this difference to increase over the next few years until 65 percent or even 70 percent of the total NASA budget will go to the *Apollo*.

Some officials put the *Apollo* percentage still higher



How NASA Is Slicing Its Budget Pies

by including such programs as the development of nuclear-powered rockets. These estimates today put the budget slice for *Apollo* at about 70 percent or more and forecast a considerable increase within the next two to three years.

On the basis of these various percentages, the *Apollo* Program and follow-on programs will spend between $35 billion and $40 billion of the total NASA budget in the 1960's.

This spending on *Apollo* can be roughly broken down further into three major areas. Officials estimate that about 40 percent—some $14 billion to $16 billion—will be spent on the *Apollo* spacecraft. And the remaining 20 percent—$7 billion to $8 billion—will be spent on *Apollo* launching complexes and technical facilities.

The clear overshadowing of all other NASA programs by *Apollo* has called into question among a number of congressmen and in industry the workability of NASA's recently restyled organization.

Worried critics argue that the agency's organization appears to be unrealistic in that it gives equal position along with the *Apollo* Program to the three offices under which all other programs are grouped.

They contend that many parts of the overall *Apollo* Program are scattered in these other offices. Therefore, they contend the entire *Apollo* Program is not within the administrative control of its appointed chief, Director D. Brainerd Holmes of the Manned Space Flight Office.

Instead, they argue, the only official holding all of the *Apollo* strings along with the strings to all of NASA's other programs is Associate Administrator Robert C. Seamans.

NASA officials counter that Holmes is the boss of the *Apollo* Program, that he is directly responsible for the development of the propulsion systems and spacecraft and their overall integration and that he has all of the authority that he needs to do the job.

As Seamans, himself, put it recently:

"We have given the Manned Space Flight Office the tools to do the job within reason. When you come to gathering data, they can receive from the Space Sciences Office whatever is needed. If a nuclear-powered rocket should be found necessary in a few years, we will transfer the rocket to them."

• **Proof to come**—Any judgment as to criticisms of the NASA reorganization will have to await future events. NASA is convinced that the future will prove that its reorganization was a good one.

The future also will show whether NASA has been right in resisting some congressional suggestions that a special non-profit company be established to provide technical assistance in the *Apollo* Program.

"In some cases setting up such a company is the best way to get on with a job," one official said. "But it adds complications, too. You are better off without it if you don't need it. We think that we won't."

All problems taken into consideration, NASA's top officials feel that their agency in notably short order has swallowed and assimilated a tremendous increase in its funding and programing, has reorganized itself and is in a position to move ahead swiftly with confidence.

"Our new manned and unmanned space science, exploration and application programs constitute the largest peacetime research and development endeavor in the history of our country," Webb said earlier this month. "The U.S. space program, as now organized, is truly a national effort."

That effort is now on its way. ¤

Apollo Team to Be Chosen by mid-'62

One prime system contractor, three or more associate primes to head huge list of contractors in $10-billion undertaking; a report on the major technical problems

A DEADLINE of June 30, 1962, is being set for assembling of the giant industrial team which will undertake the building of the *Apollo* lunar spacecraft at an estimated cost of $10 billion.

This deadline will leave just a little more than five years to construct the hardware to accomplish the hoped-for U.S. manned landing on the moon in 1967. At least 10 *Apollos* will be built.

After months of deliberation, NASA has decided in recent days to handle development and production of the whole *Apollo* spacecraft under the direction of one prime systems contractor, with at least three associate primes. There will be some 5000 supporting subcontractors and vendors.

Here's the new industrial plan:

—The prime systems contractor, to be named next month, will build the three-man *Apollo* command module and its immediately connecting service module. (The latter module will be left behind on takeoff from the moon for the return to earth.)

—In about two months, NASA will ask for proposals to select associate primes to develop 1) the lunar landing propulsion module, 2) the complete guidance and control system, and 3) the orbiting laboratory module. Contracts for the three systems are to be awarded by June 30, 1962, to associate primes who by that date will, in turn, have lined up subcontracting teams.

From an industry standpoint, the building of *Apollo* is thus to be approached somewhat in the manner of the Navy's *Polaris* program.

The *Apollo* spacecraft is managed by the new Manned Spacecraft Center headed by Robert R. Gilruth being set up at Houston, Tex. Gilruth in turn reports to the Office of Manned Space Flight in Washington, directed by D. Brainerd Holmes, where the entire lunar effort is being supervised by NASA.

• **Money picture**—Some $200 million is available under the FY '62 budget for *Apollo* spacecraft R&D. But no money has been released, pending contract awards.

The FY '63 budget is expected to include a sharp increase—probably around $535 million—to get the program rolling into high gear. By FY '64, more than $1 billion a year probably will be pumped into the spacecraft.

NASA officials connected with the program feel that over the next five to eight years the cost of the spacecraft will total in the neighborhood of $10 billion. Fully half of this figure may go to the prime systems contractor for systems engineering and for building the command and service modules.

The *Mercury* program, which is being phased into *Apollo* after the first manned orbital flight, will continue under the Houston Manned Spacecraft Center as an interim step to gain more technical inputs for *Apollo*.

At least three and possibly four manned three-orbit *Mercury* shots aboard *Atlas* are planned. In 1963-64, about three 18-orbit flights have been scheduled. Proposals also are being considered for putting a biological *Mercury* containing a monkey and other specimens into orbit for 14 days and building a larger capsule to orbit either one or two men for as long as a week.

Moreover, an orbiting *Mercury* capsule will be used with a maneuvering *Agena B* in a rendezvous experiment to determine the feasibility of this approach for assembling a lunar vehicle in space (M/R, Nov. 6, p. 18).

• **Technical problems**—Of the myriad of problems facing manned spacecraft designers, three seem to overshadow all others: radiation shielding, micrometeoroid protection and re-entry.

By careful shaping of the lunar trajectory, spacecraft designers are confident that they can avoid the high radiation levels encountered in the Van Allen belts. However, they point out, even if the mission were aborted and the only means of return were through these radiation belts, the crew would be relatively safe due to their high-speed passage and the protection offered by the spacecraft structures and equipment.

The craft's structures and equipment also will be the main shield for the crew against solar radiation. NASA designers point out that ablative materials provide protection from all kinds of radiation and for that reason are almost adequate within themselves. By spot-shielding to protect vulnerable parts of the craft, the hazard can be even further reduced.

However, no matter what steps are taken to shield the crew, they will not be sufficient protection against high-energy protons streaming from the sun during periods of solar activity. Therefore, a system of "weather forecasting" solar storms will be needed before the *Apollo* craft is allowed to venture

ONE-THIRD-SCALE model of probable Apollo re-entry vehicle design is tested in Langley tunnel.

LUNAR LANDING of Apollo (left) will probably be made with solid rockets; takeoff (right) may use LH_2-O_2 combination.

from the earth's protective atmosphere. If the craft were caught in space during increased solar activity, the crew would have to abort the mission and return to earth.

The whole area of the biological effects of solar radiation and the effectiveness of shielding materials is still very imperfectly understood. For this reason, the 14-day-orbit satellites will carry live recoverable experiments. It is necessary to recover the specimens, according to one NASA official, in order to assess the cellular and neural damage which may not become apparent until many days after exposure.

Another danger of the space environment which must be taken into account by spacecraft designers is the possibility of micrometeoroid penetration of the craft. To illustrate the seriousness of this problem, NASA engineers point to the fact that we know very little about the densities or mechanics of discrete particles in space. And, since earth simulators are inadequate to dispel our ignorance, experts disagree by several orders of magnitude on the effects of particles on the spacecraft.

The Russians, it is noted, revealed that Titov's *Vostok II* was "dented" by meteoroid impacts. The question that still has not been answered is what the Russians mean by "dented".

By assuming the worst possible conditions, the spacecraft designers feel, they can provide a mechanism to defeat particle penetration. This, they believe, is necessary to safeguard the crew from the secondary effects—ionization and richochet. Again, they stress that the ablative material of the spacecraft offers some protection to the crew. And, by providing double-walls with a damping material between them (M/R, Oct. 30, p. 32), they can defeat the penetration problem.

The fuel tanks, as well as the manned command module, must be protected from meteoroids. However, according to one NASA engineer, this can be accomplished by using ablative materials on the afterbody sections and without the use of double-walled structures.

Much more data on the mechanics, density and penetration effects of micrometeorites is expected to be available by the time the *Apollo* craft is ready for launch.

• **Re-entry problem** — After approximately two years of testing models of various re-entry bodies, it appears that a spacecraft with an lift-to-drag ratio of .5 will be used for the *Apollo* mission. The actual shape of the vehicle will be either a rounded half-cone or a symmetrical, blunted cone. In either case, the re-entry vehicle will be equipped with control flaps for maneuvering in the atmosphere.

With the vehicle hurtling into the atmosphere at 25,000 mph, the effectiveness of an ablation heat shield is brought into question. Extremely effective in blocking convective heat transfer, the ablation materials, it is feared, might be relatively transparent to radiative heat transfer.

A solution to this problem might be found in the use of charring ablation materials such as phenolic nylon or fiberglas phenolic. More detailed studies of these materials are necessary, however, to insure that they will be strong enough to withstand flight vibration, noise and thermal shock.

As the entry speed increases, NASA engineers point out, the experimental and theoretical knowledge available is meager, particularly in the areas of non-equilibrium chemical behavior, radiation heating and extensive ionization. More attention, they claim, should be devoted to experimental programs in these areas.

• **Utilize the crew**—One of the major objectives of the spacecraft designers is to make maximum use of the crew during the flight. The three-man *Apollo* team, they say, will not merely go for the ride but will perform whatever operations do not require a reaction time beyond that of man.

Onboard control of the mission they stress, is implicit in manned flight of any vehicle. This is especially true when the flight time is long, communications with the earth are tenuous and unknown situations are likely to occur.

This decision to utilize the crew creates several problems for the designers, such as determining the functions within mans' reaction time, designing and building onboard displays of the guidance and navigation parameters and determining how to get the most out of the crew. The planned flights in earth orbit using both the Mark II *Mercury* capsule and the *Apollo* spacecraft should provide answers to these problems.

One of the chief ways in which the engineers hope to utilize the *Apollo* crew is as a backup for more precise,

MODELS USED in Langley's Hypersonic Wind Tunnel to study rocket-boosted glide vehicles include (from left): a basic flow and heat transfer wing, a basic wing-body combination, and two re-entry vehicles. Tests are conducted at Mach 18.

automatic systems. For example, during the midcourse phase of the flight, one of the crew could take optical sightings on pre-determined stars for course corrections. The concept, one NASA engineer pointed out, is analogous to a ship's captain taking periodic sightings on the stars with a sextant.

Other areas in which the crew may be used include:

—Picking out the lunar landing site and monitoring the ship as it lands.

—Checking out and launching the ship from the lunar surface.

—Exercising control during re-entry in order to determine the landing point on the earth.

Two of the main advantages of putting the crew to work are: it reduces the complexity of the module construction by allowing the men to act as back-up for some of the system components; and it enhances the overall safety and reliability of the spacecraft by permitting the crew to monitor the launch countdown, initiate escape in the event of a malfunction or override ground commands.

This reliance on crew functioning has caused NASA to specify a "shirt-sleeve" environment within the command module. This eliminates the pressure suit worn by the *Mercury* astronauts because of its limited mobility and the excessive amount of time required to get into this type of suit. Therefore, there is a requirement for a "quick-don" suit to protect the crew in an emergency. This suit must contain its own integral life support system.

• **Spacecraft components** — Within the command module will be all of the equipment necessary to fly the spacecraft and to provide a safe environment for the crew. This includes the guidance and navigation systems, communications, life support and re-entry and landing systems. Also, the propulsion required for mid-course path control and velocity corrections on the return flight from the moon.

The service module—located to the rear of the command module—will consist of the experiments and components necessary to accomplish the mission while on the lunar surface. The propulsion system for the return flight will be housed, to a large extent, within this module.

The final module is the propulsion unit used during the out-bound trip for path control and velocity corrections. Also within this module will be the lunar landing package—a system with telescoping legs for landing on the lunar surface. This will also act as a launch pad for the command module's take-off on the return trip.

In discussing the propellants to be used in the *Apollo* spacecraft, NASA officials stress that the selection will be based on the present state of the art. Specifically, if the engines are liquid, the propellants will be the type used in the *Agena-B;* if solid, which is considered unlikely, they would be of the type used for the *Minuteman.*

The propellant combination of the *Agena-B* consists of Unsymmetrical-dimethylhydrazine and Red Fuming Nitric Acid. The advantages of this type of propellant system are: excellent storability, hypergolic ignition and smooth combustion, regenerative cooling is relatively easy and the state of the art is well advanced as a result of *Agena* engine development.

A back-up program will be initiated, according to one NASA official, on a Liquid Hydrogen-Liquid Oxygen system. However, whether such a system can be used will depend on the state of the art at the time of the *Apollo* flights. It is unlikely that this more exotic propellant combination will be used on early flight missions—although it may be included in later flights.

Power for the *Apollo* craft will be supplied by chemical batteries and a fuel cell. The bulk of the total wattage required will be provided by the primary fuel cell—a non-regenerative device that will provide electrical power by fuel combustion. The power requirements for the *Apollo* craft, according to one NASA official, are: 1.5 kw continuous power and 3 kw peak power. Although the state of the fuel cell art is not as advanced as NASA would like, the system offers clear-cut advantages over other power systems such as solar cells or dynamic power sources.

Solar cell, NASA engineers say, are out because of the large appendages that would be required to produce the power and the necessity for a large storage capacity while the system is operating in the shade. NASA discounts dynamic power sources because of the rotating machinery involved and the lower efficiency obtained as compared to the fuel cell.

These are the principal problem areas faced today by the designers of the *Apollo* spacecraft. ⌗

Microdot Awarded Contract on Midas

LOS ANGELES, CALIF.—Contracts in excess of $225,000 have been awarded to Microdot Inc. by Philco Corporation's Western Development Laboratories for UHF narrow-band data link transmitters and subassemblies to be flown in the Midas missile alarm satellites.

The Midas project, under cognizance of the United States Air Force, is aimed at development of a national early warning capability through multiple satellite coverage of the earth's surface via infrared detectors. Philco, with responsibility for the instrumentation, is an associate contractor to the Air Force. Lockheed Missiles & Space Company, prime system contractor, is responsible for the total vehicle and ground elements of the system, integrating associate and subcontractor efforts.

Microdot model 2406A UHF Telemetry Transmitter, similar to units now in production for the Midas satellite program.

In May, 1960, Midas satellite was launched into near perfect orbit 300 miles in space. This was followed by another successful orbit in July of this year. And, last month, Midas IV– in orbit–spotted the launch of a Titan ICBM within two minutes after the missile left the launching site. Continuation of test firings are anticipated with the program remaining a high priority national development.

For Midas, Microdot will supply their Model 2406A Telemetry Transmitter modified to include self-monitoring and telemetering of its own operation. The transmitter is miniaturized, pressurized, and includes its own solid state power supply. Reduction in size is gained through use of a unique automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. The transmitter weighs 12 pounds. Similar Microdot telemetry equipment has been a part of such projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone, and Echo I.

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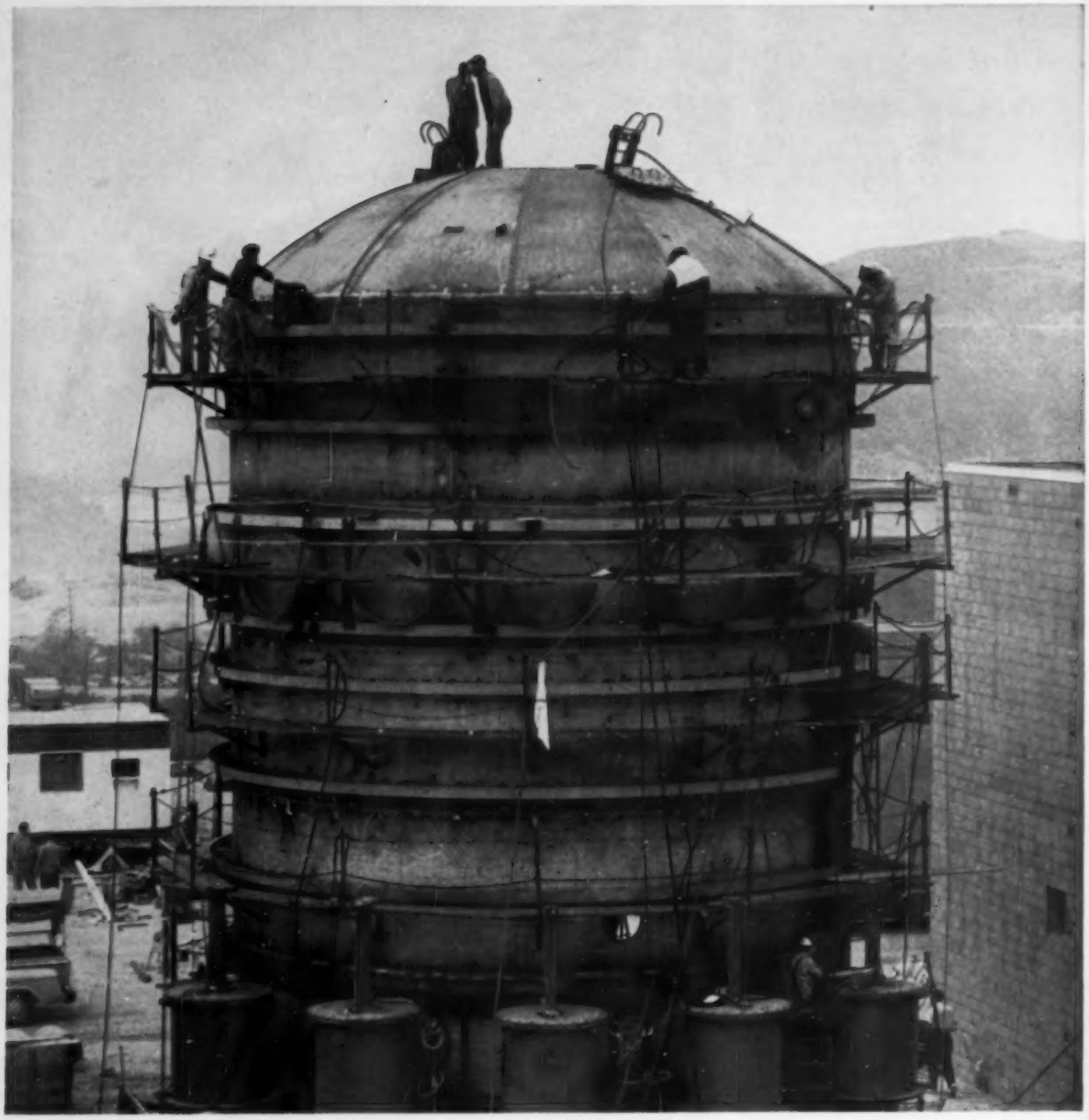

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The 80-foot high simulator will soon begin environmental tests on the Mariner — first spacecraft scheduled to fly-by Venus. In a 25-foot-in-diameter chamber, the Mariner may be exposed to a vacuum of 5×10^{-6} millimeters of mercury, a wall temperature of −320°F, and a radiant flux of sun light and heat found as near to the Sun as Venus and as far away as Mars.

Next-to-the-real-thing testing is part of any R & D work. But in JPL's job — exploration of our Moon and planets — the stakes were never higher.

The odds for JPL's (and the nation's) success in space are only as good as our scientists and engineers are good. JPL is looking for good people. The best people. Why not write to us and find out if you can improve the odds.

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MARTIN NUCLEAR ROCKET PROGRAM

- REACTOR DESIGN
- PROPULSION REACTOR START-UP
- NUCLEAR ROCKET SAFETY ANALYSIS
- RADIATION EFFECTS ON ROCKET SYSTEM
- FUEL ELEMENT DEVELOPMENT
- VEHICLE DESIGN
- CRYOGENICS

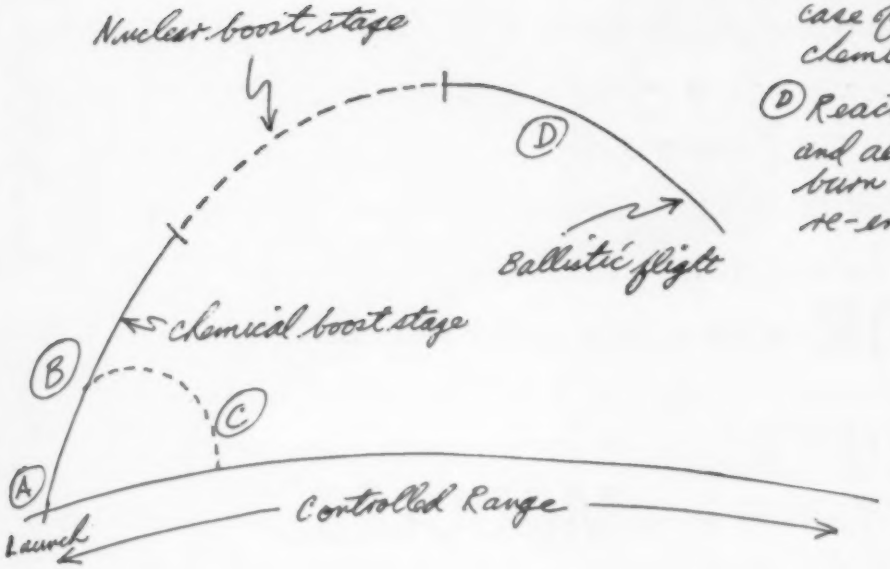
Safety Requirements

(A) Safe disposition of reactor in case of launch pad abort

(B) Rapid reactor start-up without risk of a nuclear excursion

(C) Safe disposition in case of abort during chemical boost

(D) Reactor fragmentation and aerodynamic burn-up during re-entry

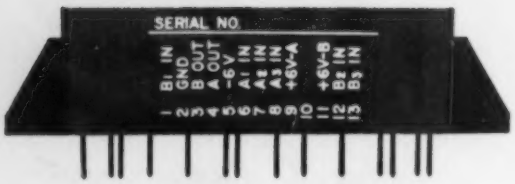


SAFETY ASPECTS OF NUCLEAR ROCKET FLIGHT TESTING

Safety is one of the many areas receiving continuous attention in the U. S. nuclear rocket program. Tests must be conducted to obtain data, to develop safety systems, and to demonstrate safety.

During the past several years, Martin has gained valuable experience in the safety field through its investigations and tests concerning the use of radioisotope-fueled generators for auxiliary power in space. Analytical investigations of nuclear rocket safety conducted by the company under the RIFT (Reactor in Flight Test) program for the National Aeronautics and Space Administration are being continued. The U. S. Atomic Energy Commission's SNAP program, under which The Martin Company developed the radioisotope-fueled generator that powers two radio transmitters in a Transit satellite, involved exhaustive safety studies and tests. This was the first use of atomic energy in a space vehicle. Experience in computer analysis of booster behavior, flight test of large boosters (VIKING, VANGUARD, TITAN and PERSHING) at Cape Canaveral, re-entry, system integration, missile test range control and rocket destruct systems, as well as extensive experience in nuclear technology, has been invaluable in the development of technical capabilities and facilities required for these investigations.

MARTIN



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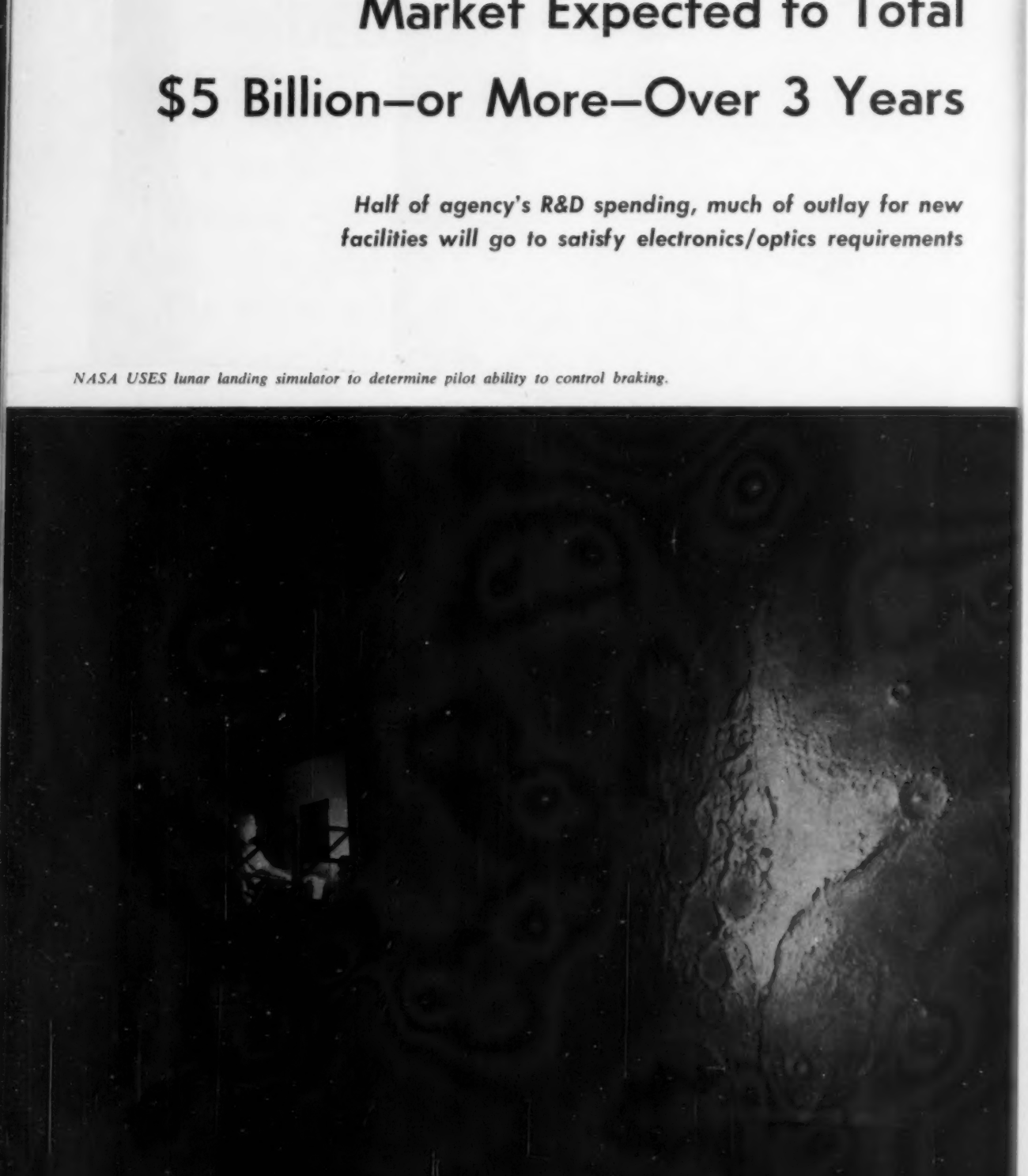
Half of agency's R&D spending, much of outlay for new facilities will go to satisfy electronics/optics requirements

NASA USES lunar landing simulator to determine pilot ability to control braking.



AS NASA'S budget booms, so do its electronics and optics requirements. Not a big production factor, this nevertheless will result in a substantial dollar increase for the entire industry.

M/R editors estimate that half the space agency's $1.3-billion authorization for R&D alone will go for advanced electronics and optical systems.

Representing an outlay of between $600-$660 million, the principal requirements will be for satellite instrumentation (over $215 million), man-in-space programs (at least $100 million), *Saturn* development (over $80 million), and tracking and data handling (nearly $40 million).

In addition to these expenditures, NASA will spend nearly $1 billion over the next three years for new facilities. A sizable portion of this will go for electronics and optical hardware.

The trend in recent years has been for electronics requirements for both the military and for NASA to equal about 50% of total expenditures for hardware and R&D. If this trend continues—and there is no apparent reason why it should not—NASA electronics needs will top $5 billion over the next 3 years.

Increased emphasis in new areas may nudge this estimate even higher. For example, the current excitement concerning the need for orbital rendezvous might change the picture. NASA officials have indicated that up to $160 million may be spent next year in this area. Some of this would be for development of simulators to teach astronauts rendezvous and docking techniques. Other problem areas will be tracking, fine thrust control and better guidance techniques.

• **Instrumentation**—An R&D salesman for optical and electronic hardware should go wild with anticipation over NASA's instrumentation requirements during the next few years.

The space agency is authorized to spend nearly $220 million for its scientific, meteorological, and communication satellites during FY '62. For studies and hardware development in its lunar and planetary-exploration program, from $80-90 million will go for electronics/optics R&D.

On top of this, NASA's huge facility construction will open up broad markets for ground telemetry, test and checkout equipment, dynamic and environmental test systems, recorders, and other types of equipment needed at large launch and test facilities.

About $200 million will be spent to build the massive static test firing facility at a site not yet selected in southwest Mississippi. Under the direction of Marshall Space Flight Center, the facility will be finished in three years. Later expansion is expected to push the total to over $400 million. Construction starts next spring and contracts for instrumentation will follow shortly thereafter. NASA's problem now is to determine the exact mission of the facility and the types of stands required.

A similar situation exists for the Space Task Group. Its new Manned Space Flight Laboratory at Houston, Tex., will initially cost about $60 million, and its completion will also require about three years. A large portion of the equipment requirements will be for advanced simulators and a variety of test equipment.

The Cape Canaveral extension for *Saturn* and *Nova* launch facilities will cost over $500 million. Construction starts next spring; completion date is 1966.

Biggest electronics outlay will be for blockhouse instrumentation, test and checkout equipment, electronic instruments for the new bio-medical center, and an extensive closed-circuit TV system throughout the vast complex.

• **Guidance and control**—G&C responsibilities are spread throughout half the NASA establishment. Marshall is responsible for launch vehicles development. To that end, it has control over G&C systems used up to the time the vehicle is operational. Thus, Marshall has been concerned with the *Centaur* guidance, electronics, and control systems and with the early G&C for *Saturn*.

A decision still must be made as to which Center—Marshall or JPL—will manage development of the advanced systems for *Saturn*. JPL has responsibility for mission planning and development of spacecraft for lunar and interplanetary exploration. For this reason, it has a direct interest in the type and capability of guidance chosen for the big booster system.

Langley developed the *Scout* launch vehicle, including its inertial reference system. Also, this Center is developing space-rendezvous and docking techniques for manned spacecraft.

Ames also has responsibility for selected research in spacecraft stabilization control and orientation. Much of its studies have centered on human capability for guidance, control and navigation of multistage launch vehicles.

In other programs, such as *Nimbus* and *OAO*, Ames developed G&C criteria. The Center is working with M.I.T. now on *Apollo* guidance. The group will study the overall problem with regard to mission requirements and may possibly study alternate G&C configurations not being investigated by M.I.T.

Both Lewis and Langley are studying lunar soft-landing problems.

Goddard originally directed development of the control system for *Mercury*. Now that Space Task Group is a separate entity, it assumes responsibility for Project *Mercury* and *Apollo* and, of course, the development of their G&C systems.

Goddard retains direction of control and stabilization systems for all scientific and application satellites except two groups: the micro-meteoroid and *Echo* satellites being developed by Langley.

NASA expects to spend about $16 million during FY '62 for R&D of guidance and control systems. The total for *Apollo* is expected eventually to be from $20-30 million.

R&D expenditures in this field are not expected to change much over the next few years. Total market figures for complete systems including GSE will rise steadily from the present $85 million to roughly $500 million in the next 5 years, according to industry estimates.

These figures, some observers feel, could be reduced even with the expected increase in number of units required. They expect up to 75% reduction in unit costs over the next 10 years.

There are still many technological problems in this field, but in general

M/R Estimates of NASA FY '62 Expenditures for Electronics/Optics R&D*

	(Millions)
Research Grants & Contracts	$ 3.0- 3.5
Life Sciences	7.0- 11.0
Sounding Rockets	3.4- 4.0
Satellites:	
Scientific	72.7-
Meteorological	50.2-
Communication	94.6-
Lunar & Planetary Exploration	80.0- 90.0
Mercury	38.0- 43.0
Apollo	60.0- 70.0
Launch Vehicle Technology	10.0- 11.0
Launch Operations Departments	1.0-
Spacecraft Technology	4.0-
Scout	1.0- 1.4
Centaur	6.0- 8.0
Saturn	80.0- 95.0
Tracking & Data Acquisition (and advanced communication techniques)	38.6-
Nova	18.5- 20.0
SUB TOTAL	$568.0-618.6
Support of NASA Plant (in-house R&D)	40.0- 45.0
TOTAL	$608.0-663.6

** Based on NASA authorization for FY '62, these figures could be cut because of $75-million subsequent slash in NASA appropriations for R&D; nevertheless, NASA's January supplemental requests are expected to keep the figures where they are now.*

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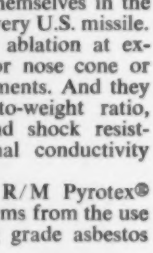

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G&C experts believe that state-of-the-art will parallel requirements.

Toughest problem may be in recovery or landing manned vehicles safely and at a selected point. Several companies are studying the problem — not only for *Apollo* but for the Air Force's *Dyna-Soar* boost glider.

In brief, these are some of the other G&C requirements noted by NASA scientists:

—A simple means for locating and identifying celestial bodies.

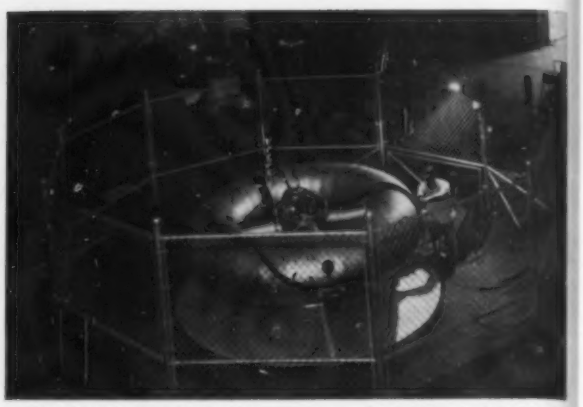
—More versatile timing, sequencing, and logical control for operation of scientific instruments in unmanned spacecraft on planetary orbital or landing missions.

—Better methods for sensing altitude and altitude-change rate and cross-velocity, particularly for soft-landings.

—Eventually, celestial midcourse guidance and navigation capable of angular measurements to an accuracy of 5 seconds.

—Attitude and inertial sensors accurate to 0.001° (these needed by 1964).

—During this decade, a guidance computer capable of performing navigation, storage and processing of scientific data, and spacecraft control during near-surface maneuvering for exploration.



LANGLEY TECHNICIAN prepares 10-ft.-diam. (⅓ scale) model of possible erectable manned space station for test in which model is spun to simulate artificial gravity technique.

• **Tracking and data handling**—At present, Goddard is responsible for tracking and the acquisition, processing, and reduction of data for all space missions. It operates the Minitrack net as expanded from the early system set up for the International Geophysical Year. This includes 13 Minitrack stations and a new station at Fairbanks, Alaska.

Also, Goddard is responsible for the *Mercury* net, which consists of an 18-station global complex. Langley directed the establishment of the $80-million system and now manages the ground instrumentation and tracking facilities for Goddard.

Goddard actually operates five stations, DOD handles the others.

JPL has responsibility for the new Deep Space Instrumentation Facility (DSIF), which will be capable of tracking and communicating with deep space probes and manned lunar flights of the future.

All of the existing and planned facilities are continually up-dated. R&D authorization of nearly $40 million this year (FY '62) is indicative of the extent of this work.

As it stands, Minitrack operates in the 136-mc band. It provides extensive narrow-band coverage, but is limited by information rates.

A new wideband net is now being integrated with the system. The first station, at Fairbanks, uses an 85-ft. dish providing very high gain. System electronics will be checked out by the end of 1961.

Two more stations will be installed: one will be located near the East Coast of the U.S.; the other will be installed, probably in Europe, by mid-1963.

The new stations will operate in the 136-mc band and at (approx. frequencies) 400 mc, 1700 mc, and 2300 mc. Antennas will have multiple feeds, but not all stations will necessarily be provided with equipment to receive each frequency.

First uses of the expanded system will be for the R&D phase of the *Nimbus* weather satellite and possibly for S-27 (the Topside Ionosphere Sounder), and for *OGO*, *OAO*, and *OSO* follow-on satellites.

Each of the three new facilities will cost an estimated $5 million.

DSIF consists of three stations spaced 120° apart longitudinally. Located at Krugersdorp, South Africa, Woomera, Australia, and Goldstone Lake, Calif., the sites employ 85-ft. dishes. JPL maintains net control at Pasadena, Calif.

This system is considered adequate for the next few years, but for deep outer-space probes JPL is developing 250-ft. reflectors.

The *Mercury* net has yet to be operationally checked out with an orbital vehicle. It had a partial test this year during each of the two suborbital manned flights of the capsule.

Launch of a 150-lb. electronic package (carrying C-band and S-band trans-

ponders, telemetering transmitters and receivers, and two Minitrack beacons) by a *Scout* vehicle on Nov. 1 was aborted. Firing was to check out the real-time computing center at Goddard and the communications links between Goddard and the range stations.

To augment the 16 fixed ground-tracking stations in the *Mercury* net, two Navy C-4 tracking ships are being instrumented. Outfitting of the two MARS (Mobile Atlantic Range Stations) ships is being performed by Sperry-Rand. Eventual cost is estimated at near $50 million.

For the future, many experts believe, the *Apollo* program will require outfitting of at least two more similar vessels.

• **Evolution**—Modifications and overall systems improvement over the next 5-10 years will be extensive, but evolutionary, according to NASA officials. Some of the major requirements include:

—Better communications link for data acquistion by Goddard's processing center. Radio has been suggested. The Center currently uses teleprinter tape for transmission of tracking data for processing and orbital computation by the IBM 7090's.

—Reduction in power requirements for near-space tracking. In time, parametric amplifiers may be used, together with more high-gain antennas.

—More efficient, higher-powered transponders are needed, however, for deep-space probes.

—Improvements in optical-tracking readout time.

—Decrease in data reduction time. At present, 1 hour tracking time yields 1 hour data processing time. The trend toward more elliptical satellite orbits is expected to further complicate tracking/trajectory computation problems. Also, NASA expects to launch 124 satellites over next 9-10-year period, which will further complicate problems.

More information per watt of power seems to be the order of research. More vehicles means more tracking requirements, more capacity for ground data-collecting equipment, and more capability to operate over longer ranges. Improvements are needed all down the line —including a greater research effort in information theory.

—More efficient pre-editing procedures to reduce data before final processing.

These are but a few of the many problems requiring early solution. Each area is being studied or will soon be tossed out to industry for R&D. The two areas of greatest effort, however, will continue to be in network operations and communications. Funding for FY '62 alone for each is over $14 million and $9 million, respectively. ⠿

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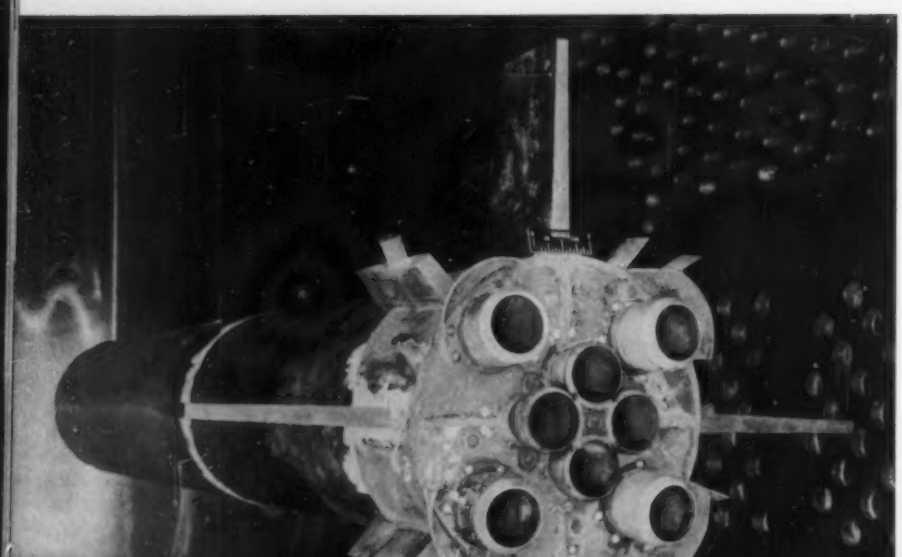


OPERATING MODELS such as this version of the Saturn Apollo booster are almost as difficult to build as the original.

THE KEY TO the U.S. space program may well be hydrogen—the fuel that promises more than a 30% increase in performance but poses a technology difficult to master.

Every major NASA propulsion effort depends on the element to some extent.

—It is the heart of the *Centaur* program, aimed at giving the U.S. a high-performance, general-purpose launch vehicle capable of handling payloads too heavy for *Thor* or *Atlas-Agena B* vehicles and too light for economical usage of the massive *Saturn* series.

—*Saturn* itself is being paced by the element, since all upper stages are slated to use hydrogen as a fuel. Hydrogen development is closely allied to a completely successful *Saturn* program.

—The *Rover* heat-transfer nuclear rocket will use hydrogen—and it is safe to assume that any follow-on nuclear engine will call for it.

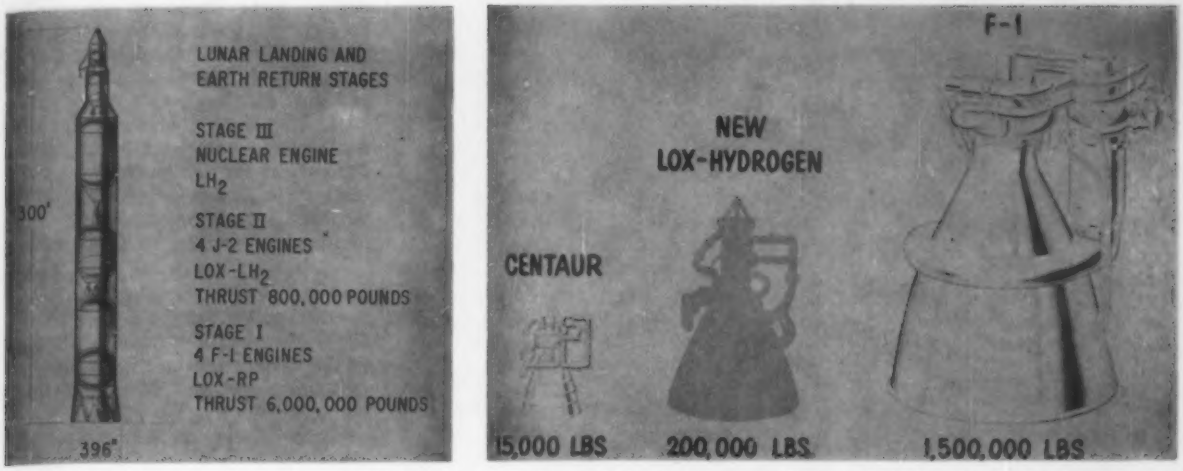
—Several funded space projects are directly dependent on hydrogen-firing booster vehicles; substitution of another vehicle means fairly drastic reductions in project payload and mission.

—The huge *Nova*-class vehicles would be committed to hydrogen in the upper stages regardless of the nature of the first two stages.

And there are hydrogen-induced setbacks in every one of these programs.

The primary hydrogen problems are in the heat transfer area. This includes storage, pumping, nozzle flow and cooling.

• **Insulation & zero-g** — Tankage alone is a complicated field. The hydrogen is useful to NASA only in the cryogenic state, and keeping it cold in space any length of time is not easy.



ULTIMATE Saturn vehicle would mate the C-4 with J-2 engines, nuclear upper stages. Here are NASA engines in development.

A pressurized system raises many questions—such as the effect of the pressurizing gas on the liquid hydrogen, and the reverse of this—the effect of the cold hydrogen on the pressurizing gas.

The position of the liquid in the tank at zero gravity is important. Preliminary experiments have shown that pressure rises faster under this condition than was previously thought. What are the best outflow methods? What are the effects of attitude control on a partially emptied tank? And again, the reverse question—what is the effect of a partially filled tank on attitude control?

The general dynamics of motion in this area is a complex problem.

In the propulsion unit itself, the hydrogen is in its critical range. Cooling of nozzles, pump configurations, insulation and other allied aspects are extremely difficult to anticipate because of the peculiar properties of the fuel under critical conditions.

One big problem at the Marshall facility involves the use of hydrogen on a lunar return trip. All of the above areas contribute to this simple question—can the fuel be used at all to return to earth?

There are several approaches to this problem. One of these, proposed by Thiokol Chemical Corp., is under evaluation by Lewis. This involves a return mission capability through "space-storable" propellant systems such as oxygen fluoride and methyl monohydrazine or a boron fuel (B_2H_5). These systems move the critical temperature to about −194° F instead of the −423°F liquid-hydrogen range.

In the big booster areas, the relative positions of solids and liquids have not yet been fully resolved. No major decisions are expected before next January.

Some NASA propulsion experts maintain that liquids are ahead and the U.S. is much closer to a liquid *Nova* than to one using solids. There is strong feeling in NASA against crash programs in big solids.

A small solid vehicle, resembling *Saturn C-1* in size and capability, looks attractive in that it might be more reliable; larger sizes, however, bring problems—one scientist pegs the problem area at above 12-million-lbs.-thrust.

The consensus seems to be that no one has anything against solids, that starting development in this field is advisable, but crash programs are unnecessary.

The rendezvous approach currently being mentioned in connection with the manned lunar effort is definitely a point in favor of liquids. NASA is considering a returnable command module for *Apollo* weighing about 12,500 lbs. A lunar landing system must be capable of 50,000 lbs. deposit and about 13,000 lbs. return. Thus a *Nova* is necessary for direct flight and the *Saturn* series for the orbital approach.

Within this framework, the *Saturn C-4*, 6-million-lb.-thrust first stage of four F-1 engines, will be the rendezvous work horse. There is some talk of upgrading the F-1 to an F-1-H or F-Y using liquid hydrogen. This would place the *C-4* almost in the *Nova* class. It also again underlines the importance of hydrogen technology to the whole space effort.

• **Planetary engines**—Space electrical propulsion currently carries an authorized expenditure figure of around $6.8 million. NASA is developing three types of electrical rockets designed to meet the propulsion requirements of deep space, the areas beyond the big chemical rockets.

The ion engines are closest to actual flight testing: some environmental space runs are scheduled for 1962. A flight version of an ion engine is being built at the Lewis Research Center for tests in harness with the Hughes unit. All electrical propulsion work is now concentrated at this center.

Development is proceeding on arc jet (electrothermal) engines and magneto-fluid-dynamic units. All of these engines are eventually to be utilized for planetary missions.

NASA's highly classified work in nuclear rocket systems is known to be progressing at a more-than-satisfactory pace. The *Rover* heat transfer rocket has an authorized price tag of around $25.5 million, including flight test engine development.

Fiscal '62 will see the installation of liquid hydrogen turbo-pumps and liquid hydrogen-cooled nozzles in the *Kiwi-B* reactor series. Development of these components for higher-power reactor tests will also be initiated.

Work in such areas as radiation effects and shielding, hydrogen properties evaluation and the necessary instrumentation, is already in progress within NASA.

While the reactor work itself receives a great deal of public attention, there is a large amount of support effort in the many components. The effect of reactor radiation on materials at cryogenic temperatures is being studied—as are bearings and wheels at high temperatures.

• **H_2 headaches**—The high heat flow from the hydrogen jet to the nozzle walls means that liquid hydrogen will have to be used as a coolant. This noz-

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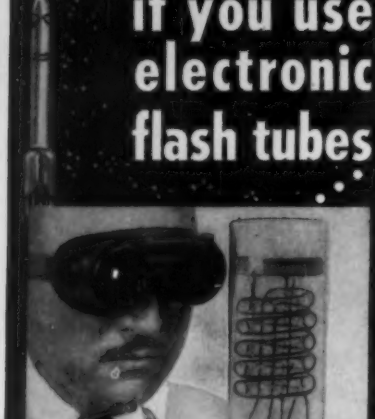

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zle cooling problem is one of the big unanswered questions in nuclear rocket technology.

The nuclear engine exceeds even the heat flow to the nozzle wall of a hydrogen-oxygen engine. Heat flaws are expected to be 50 to 100% higher than those experienced in the H_2-O_2 unit.

The whole *Kiwi-B* series of tests are intended to lead to a reactor which can be incorporated in the *Nerva* (Nuclear Engine for Rocket Vehicle Applications) engine. The *Nerva* engine is currently in early development, and NASA believes it essential to conduct flight tests as soon as possible to obtain design information—and also to provide confidence in the solution of any unexpected problems resulting from the flight environment.

The first flight tests, expected in 1966-67, will involve ballistic trajectories to exactly pre-determined impact points, using first-stage *Saturn*-class boosters. Safety measures will be such that the minimal hazard, regardless of events, is too small to really comprehend.

Continual development of this flight test system could lead to operational third stages for *Saturn*. Such a nuclear third stage would increase the escape payload of a chemically propelled *Saturn*-class vehicle by a factor of 3.

• **Overall R&D**—In the general area of propulsion development, NASA has been authorized about $96 million—$93 million of it in liquids. The bulk of the liquid funds are in the F-1 and the hydrogen-LOX, 200,000-lb.-thrust J-2.

Some in-house basic research is also being carried out. One example is

NASA's Launch Schedule Through the Fourth Quarter of 1962

Payload	Launch Vehicle	Site	Period
Electron Density P-21 Satellite	Scout	W.I.	4th Quarter 1961
Tiros IV Meteorological Satellite	Delta	AMR	"
Electron Density P-21a Satellite	Scout	W.I.	"
Ranger II	Atlas Agena B	AMR	"
Echo Satellite	Thor	AMR	"
MA-6 (Manned earth orbital flight)	Atlas	AMR	1st Quarter 1962
Ranger III (Lunar rough landing)	Atlas Agena B	AMR	"
MA-7 (Manned orbital flight)	Atlas	AMR	"
Orbiting Solar Observatory (OSO)	Delta	AMR	"
Electron Density P-21a Satellite	Scout	W.I.	"
Topside Sounder S-27 (Canada)	Thor Agena B	PMR	"
Ionosphere S-51 Satellite	Delta	AMR	"
Tiros V	Delta	AMR	"
SA-2 (Second Saturn C-1 launch)		AMR	"
Ranger IV	Atlas Agena B	AMR	2nd Quarter 1962
MA-8 (Manned orbital flight)	Atlas	AMR	"
Rigid Passive Communications Satellite A-12	Thor Agena B	PMR	"
			"
Project Telestar (AT&T Communications Satellite)	Delta	AMR	"
Scout Re-entry Test	Scout	W.I.	"
Energetic Particles Satellite	Delta	AMR	"
Orbiting Solar Observatory Backup	Delta	AMR	"
Telestar Backup	Delta	AMR	"
Tiros VI	Delta	AMR	3rd Quarter 1962
Scout Re-entry Test	Scout	W.I.	"
Venus Flyby	Atlas Agena B	AMR	"
Venus Flyby	Atlas Agena B	AMR	"
Relay Communications Satellite	Delta	AMR	"
Fixed Frequency Topside Sounder	Scout	PMR	"
Orbiting Solar Observatory S-17	Delta	AMR	"
Relay Communication Satellite	Delta	AMR	4th Quarter 1962
Telestar Communication Satellite	Delta	AMR	"
Electrical Engine Test	Scout	W.I.	"
SA-3 (Third Saturn C-1 Launch)		AMR	"
Nimbus Meteorological Satellite	Thor Agena	PMR	"
Ranger V	Atlas Agena B	AMR	"
Tiros VII	Delta	AMR	"
Syncom Communications Satellite (22,300-mile altitude)	Delta	AMR	"
Telestar Backup	Delta	AMR	"
S-48a Backup	Scout	PMR	"

an attempt on the part of Lewis scientists to take advantage of the "screaming" process in liquid engines. This high-frequency, high-amplitude acoustic oscillation has resulted in engine failures. This aspect was eliminated by inserting fins. The group is trying to relate the mechanism driving the high-pitched "screaming" waves to present theories of steady-state combustion.

There is also some small research effort into the burning process in solids. Part of this is geared to production of pure hydrocarbon binders which would be less reactive with high-energy additives such as lithium perchlorate.

In the *Scout* program, NASA will aim in FY 1962 for improved motor capability. Increased cone diameter, vehicle design standardization and component qualifications test completion are other *Scout* aspects due for early concentration.

Since *Delta* vehicle and engine development has been completed, all 1962 funds in this area are allotted for contractor launch services.

The *Centaur* program is in the forefront of hydrogen technology. It ran head-on into the whole hydrogen fuel development area—uncovering a host of problems with the high-energy fuel.

The *Nova* concept may be downgraded in favor of a major development effort for a *Saturn C-4* vehicle. Some NASA propulsion experts have stated a preference for building one vehicle at a time—not both *Nova* and *Saturn C-4* simultaneously. Primary reason—a better job will be done.

Certain NASA spokesmen say the recently completed "Golovin" study is not the complete answer, and that NASA Administrator Webb is not obligated to buy all of the committee's recommendations.

The committee called for parallel *Nova* development with direct lunar flights in mind, and suggested the funding of the Air Force 120-in.-diameter solid booster.

The Jet Propulsion Laboratory has requirements for chemical-type orbiting retrorockets which will remain in operational condition over a 3- to 6-month time span while traveling to other planets. The facility is reviewing both solids and storable liquids.

JPL has no definite plans, at the moment, as to how and where electrical propulsion systems will be used. Some thought is being directed, however, toward applying such systems to planetary orbit tasks. This is in addition to long-range interplanetary flights.

The lab is also looking at the possibility that *Saturn* may provide some capability for high-energy missions such as flights to Mercury and Jupiter. Details await final choice of the *Saturn* version. ⌘

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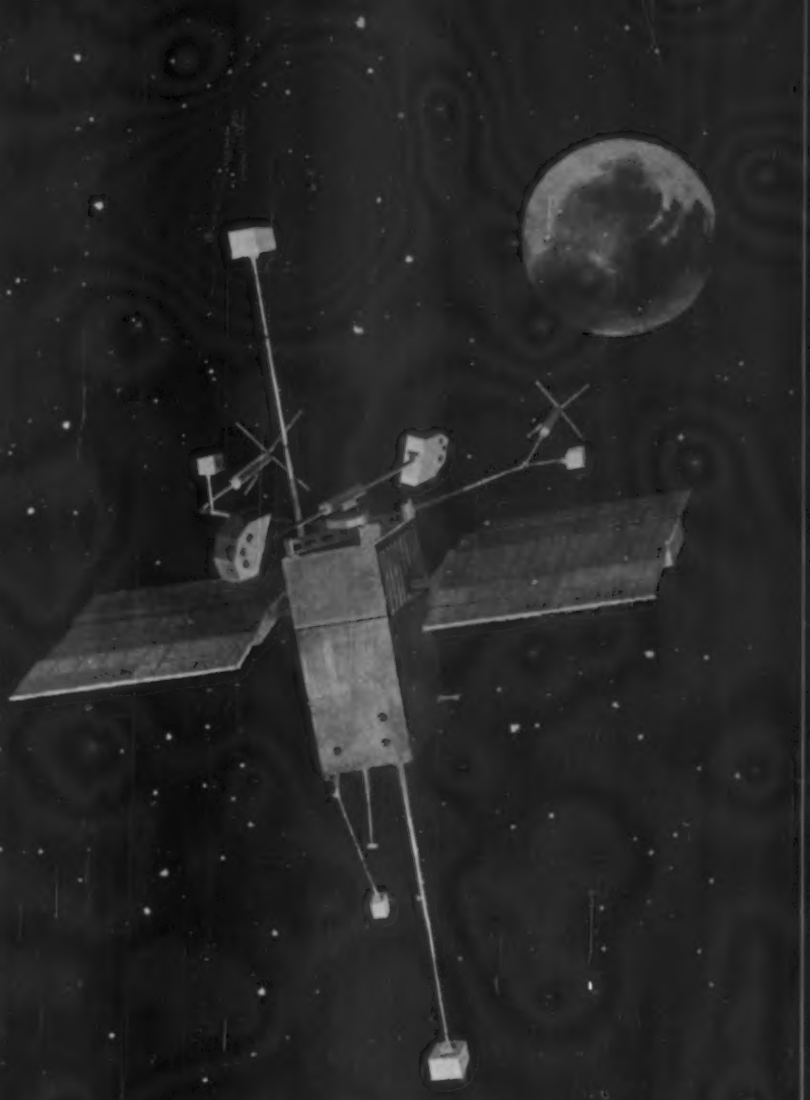

How OGO keeps its eye on the ball

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ATL is also actively engaged in the development and manufacture of other satellite stabilization components and systems, including optical rate/yaw Sensors and micro-thrust reaction control systems. Individuals interested in challenging career opportunities at this "Equal Opportunity Employer" on the San Francisco Peninsula should direct resumes and inquiries to the Personnel Department.

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Auxiliary Power R&D Funding Up 88%

NASA IS MAKING a concerted effort to develop auxiliary power units (APU's) for long-duration spacecraft.

The big push is for nuclear-electric power systems, particularly *SNAP-8*. But there is also a major drive in the non-nuclear area, as shown in the agency's funding breakdown:

—Nuclear APU R&D is budgeted for $7.7 million in FY '62—more than double the $3.5 million spent in FY '61.

—Non-nuclear APU R&D is getting $5.5 million—a gain of $2 million over the FY '61 figure.

About $700,000 is earmarked for fuel-cell work, but none of this money will be spent directly for *Apollo* APU's.

(In its quest for secondary power for *Apollo*, NASA seems convinced that fuel cells are the answer although a final decision has not yet been made. Present auxiliary power requirements for the spacecraft call for a two-week system able to reach a peak power of 3 kw, an average continuous power of 1.5 kw, and re-entry power provided by zinc-silver cells.)

• **Where the business is**—Bits and pieces of NASA's APU work are scattered throughout the agency. But all of it is under the general direction of two men at NASA headquarters: Walter Scott and Fred Schulman.

Scott is responsible for solar and chemical auxiliary power developments. Reporting to the as-yet-unnamed director of propulsion and power generation, he has in his area about 30 contracts with industry.

In general, Jet Propulsion Laboratory monitors the solar thermionic work; Lewis Research Center, the solar mechanical nuclear and fuel cell; Goddard Space Flight Center, the battery work and some radiation damage studies; Langley Research Center, some collector studies; and Marshall Space Flight Center, a small effort (battery-oriented) on auxiliary power for launch vehicles.

Reporting to Harold Finger (Director of Nuclear Systems), Schulman is responsible for nuclear electric power systems. Much of this work is done at Lewis. The Center has under contract about a dozen companies working in R&D areas related to nucleonics: materials, corrosion, advanced components work, etc. Moreover, while the AEC is supplying the reactor for *SNAP-8*, Lewis is supplying the rest of the system.

Prospective R&D contractors interested in contributing to the APU field are urged by NASA to discuss their proposals either with Scott or Schulman, and also with the appropriate space-agency center.

• **Opportunities at JPL**—JPL is very much interested in thermionic solar-conversion systems as a potential improvement over solar panel-type collectors. The Laboratory has some research contracts out in this area and will have more.

Voyager, for example, may be equipped with a thermionic solar-powered conversion system, rather than the photovoltaic solar panels now in use.

The Laboratory is also looking for better power-regulation equipment which is needed to go either with the solar-thermionic or photovoltaic conversion systems. Right now, these regulation devices have 50% losses. JPL is eager to look at anything practical that can be done to reduce this loss.

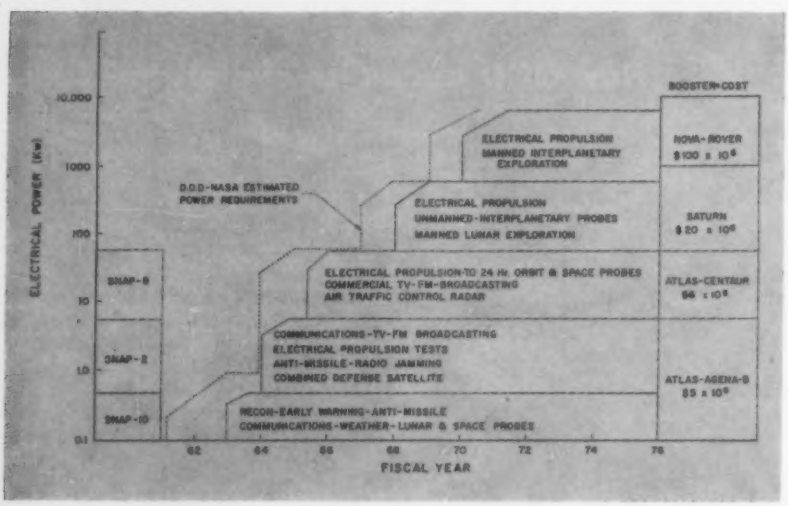
For the planetary program, its director, R. J. Parks, says: "We will be choosing components, subsystems and such principally on what we know about reliability and lifetime capabilities." He emphasized that high reliability and long lifetime are of overriding importance.

Scientists at JPL also made the following observations to MISSILES AND ROCKETS:

Up to 1965, spacecraft power systems may use voltaic cells, primary batteries and static converters and inverters. Beyond that time, when a continuous unregulated power capability of 2500 watts is wanted, photo-voltaic sources probably will not be feasible because of their high cost. Solar-or nuclear-powered thermionic or turbine generators appear to be more attractive.

Furthermore, the effort spent developing photovoltaic cells should concentrate on increasing efficiency and reducing cost. With respect to batteries, efforts over the next few years should be directed toward reducing weight and lengthening cell life. Secondary batteries should have better charge-discharge efficiency in order to ease the power requirements for orbiting missions.

(A high source in JPL's lunar exploration program feels that NASA ought to start thinking early—and now is not too early—about a manned moon



Space Power Requirements and First Flight Availability

base. He says serious studies should get under way within the next two years. At the present time, JPL is not doing anything on the moon-base problem.)

Over the next decade, the lunar exploration program will require a "family" of nuclear power sources for operation on the moon's surface. The need is for lower-power sources for transmitters and TV systems, and high-power sources for propulsion on the surface.

• **Opportunities at Lewis**—Lewis is working on fuel cells, *Sunflower* and *SNAP-8*, and invites R&D effort in areas that can support these energy conversion projects. "We are certainly interested in getting industry help . . . Tell them to get in touch with us!" a Lewis project engineer urged M/R.

The Center is monitoring a $300,000 Pratt & Whitney R&D contract calling for development of a modular fuel-cell system. (Research on an electrical regenerative hydrogen-oxygen fuel cell falls under $100,000 contract with Electro-Optical Systems, which for geographical reasons is monitored by JPL instead of Lewis.)

Lewis is also monitoring *Sunflower*, which NASA is planning to flight-test in 1966. This is a 3-kw system being developed by the TAPCO Group of Thompson Ramo Wooldridge, consisting of a foldable petal-type solar collector that will open to a diameter of about 32 feet.

The sun's rays will boil liquid mercury which will drive a turbo-generator to product electric power. The thermal-energy storage unit will permit continuous operation, even when the craft is in the earth's atmosphere.

NASA is drawing up plans to develop nuclear power-generation systems able to put out tens of kilowatts. This will be a long step beyond the *SNAP-8* units, which are expected to go into flight-test during the spring of 1965. The flight test will follow ground demonstration and endurance tests that will probably begin in late 1963.

The *SNAP-8* will come in two designs: a 30-kw configuration, with one reactor and one turbine conversion unit; and a 60-kw configuration, still with one reactor, but with two conversion units (M/R, Aug. 22, 1960, p. 39).

Many other types of APU's are being developed both by other government agencies and by industry. Specifically, there are nuclear units other than *SNAP* which may challenge some of NASA's concepts and hardware. Moreover, industry may have in its proprietary or unfunded pouch some developments that could drastically reshape the APU picture. ■

Space Power Technology Budget

(For contracted R&D—FY '62)

ADVANCED RESEARCH:	
Radiation damage	$250,000
Fabrication techniques for solar collectors	100,000
Space power systems	200,000
Thermionic conversion	300,000
Thermal energy storage materials	100,000
Regenerative fuel cells	100,000
Magnetohydrodynamic power generation	150,000
Total	$1,200,000
ADVANCED TECHNICAL DEVELOPMENT:	
Solar-cell array technology	$200,000
Power system components	200,000
Improved batteries	300,000
Sunflower-1	1,800,000
Primary fuel cells	500,000
Solar concentrators	400,000
Chemical power units	300,000
Solar-thermionic power system	500,000
Regenerative fuel cells	100,000
Total	4,300,000
Grand Total	**$5,500,000**

Nuclear Electric Power Systems Budget

(For contracted R&D—FY '62)

Advanced systems and components	2,500,000
Prototype development (SNAP-8)	5,000,000
Total	$7,500,000

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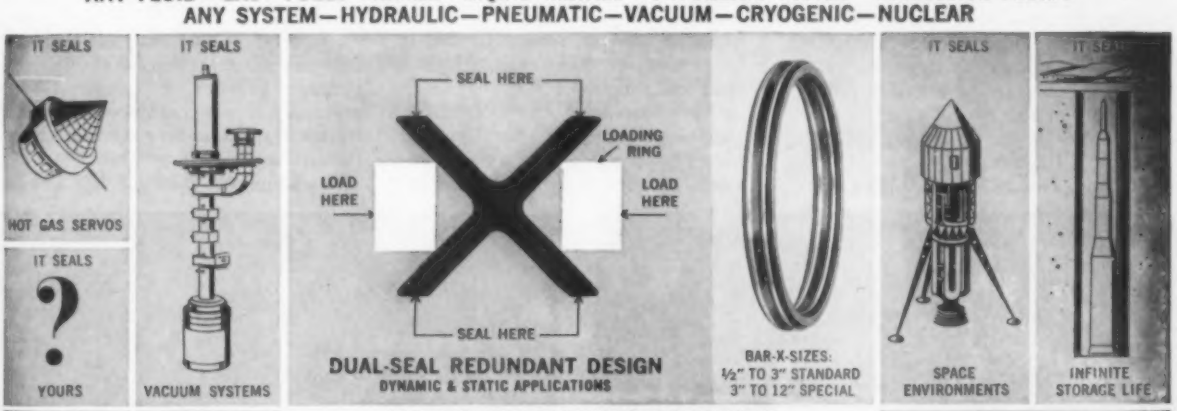

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Industry Getting More Research Work

Marshall, Langley and Lewis lead centers in materials studies; large space projects are boosting outside participation

THE BASIC TREND in NASA materials research and development is toward greater industry participation on a contract level. The whole area supports so many NASA activities and is so highly integrated with individual projects that no single dollar figure is available.

NASA has been operating on about an 86% in-house/14% contractual basis, but there are definite indications that the contracting will grow substantially. This does not mean that the in-house effort will decline. In fact, it will increase on a modest scale.

A significant amount of work in the materials areas is being done outside of NASA's direct control. This is in connection with large project contracts. The dollar amount is large, although the work being accomplished is only a small part of the overall contract.

The greater part of NASA materials research is fundamental in nature. But it is always closely allied to space functions. For instance, one group is probing magnetic fields for metal fabrication. Parts have been welded, swaged, formed and punched with these procedures.

One attractive application is in the area of space repair or fabrication. In some instances, with the proper tools, no unbalanced torque is generated—a boon to an astronaut working in a weightless environment.

The method is part of an overall investigation into the usefulness of energy-storage concepts. These techniques can be applied with only a very low average power requirement—easily supplied by current and near-future space electrical power sources.

Besides fabrication, applications include rendezvous and docking, attitude control and propulsion.

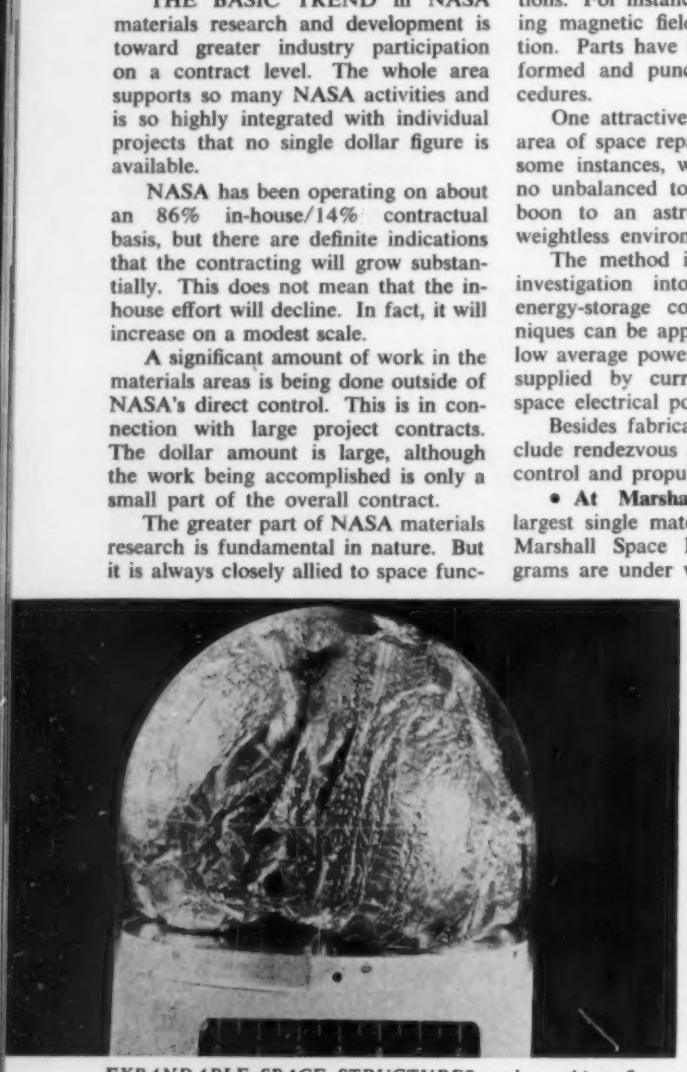
• **At Marshall**—At present, the largest single materials effort is at the Marshall Space Flight Center. Programs are under way in high-temperature pulling of metals, in corrosion, and in cryogenic properties of metals. Marshall's work is usually associated with specific space projects or planned missions.

A graphic illustration is the program to reduce the weight of paint on vehicles. This effort, in one instance, shaved 35 lbs. from the *Redstone* booster.

Other major areas cover the vacuum effects on plastic materials such as teflon, silicone and rubber. Studies are in progress with solid lubricants (Marshall scientists say no adequate vacuum lubricant exists at the present time). Seals and gaskets are being studied.

A great deal of material evaluation for protective properties at high temperature goes on at Langley. Many promising coatings developed by industry for *Dyna-Soar*-type vehicles are run through series of tests.

Innumerable materials for ablation



***EXPANDABLE SPACE STRUCTURES** such as this reflector are being actively researched at Langley. Semi-rigid models would not require constant positive pressure to maintain design configurations. Current studies into radiation-induced memory func-*

applications are also checked out at the center. Langley scientists also develop some of their own. Future materials work at the Virginia installation will revolve around planetary vehicles.

The operation is best described as basic applied research. Langley considers structures and materials to be inseparable, and the work illustrates this philosophy. Such efforts center on the fundamental behavior of thin-shell structures—an old field but one that is not satisfactorily understood.

Landing impact absorption is another area. This essentially involves reentry vehicles, but it concerns the last 30 ft. of descent.

The main limitation is in reproducing the necessary environments—it is sometimes difficult to get temperatures high enough. Langley has started a program in pyrolitic graphite, and some test facilities will have to be slightly modified.

There is concentration on materials for lightly loaded, reusable, manned vehicles, but work is progressing on all types of load-carrying structures. The very light load area is illustrated by the *Echo* passive communication satellite series.

Echo is a prime example of erectable structures; research into both mechanical and gas erection methods is in progress. In this area there are both in-house and contracted projects involving radiation-induced memory effects on plastics.

Such a development, brought to a successful conclusion, would make possible compact payloads which have "learned" a certain shape. When in space, the payload would "remember" this shape and assume it after a little thermal prompting.

Langley scientists are currently working on *Echo II*. This 135-ft.-diameter satellite will be more rigidly constructed than *Echo I*, making it possible to release the erection gas after the satellite has assumed its shape. The polyester film, sandwiched between two layers of aluminum foil, will retain its shape after escape of the balloon gas.

DATA DERIVED from subjecting a missile nose cone to simulated aerodynamic heating is part of the hypersonic flight information NASA supplies to industry.

The erection principle is being applied to a number of functional satellites besides passive communications vehicles. Solar concentrators is one fertile area.

The center is also engaged in the effect of both solar and Van Allen radiation on plastics. Hard-vacuum effects on these materials are under investigation.

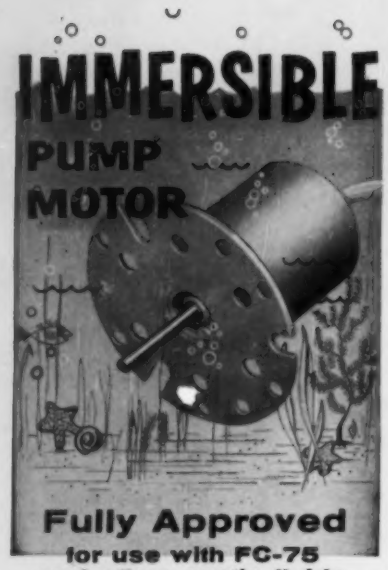
• **Metal research**—Materials work at Lewis is heavily concentrated on metals—with the exception of aluminum. Lewis spokesmen say the aluminum industry does all that is needed, but one or two highly specialized projects might be handled by NASA for a specific purpose.

Lewis is largely engaged in long-range work in the areas most closely associated with propulsion—high and low temperatures. There are seldom any specific applications in mind, since most of the research is fundamental. But the group has come up with a promising nickel-based alloy developed by J. Freche.

Molybdenum and tungsten are being alloyed with other materials to increase the crystallization temperature.

tions in certain structural plastics may completely eliminate the requirement for gas or mechanical erection systems—and

still achieve compact payload capsules. Echo II is now under development at the Langley Center.



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Porous tungsten has been fabricated for ion engine purposes, but this is another instance of deviation from long-range work to help a specific project.

The refractory metal program seems to be mainly applied to tungsten, but with a small effort directed toward columbium. There is also work in inorganics, such as hafnium carbide. A group is researching dispersion hardening in composites. Here the primary task is to get a more refractory precipitation. Aluminum oxide is mechanically inserted in some experiments.

VAPOR FORMATION, damaging to rocket engine pump blades (inset) is included in NASA propulsion research.

In physical property work, Lewis researchers have developed a simple method to predict fatigue effects through conventional tensile measurement data. The role of imperfections in reducing strength is being actively probed. Much of this work is aimed at obtaining general data for design purposes.

Lewis scientists went deep into compatibility problems in liquid metals systems. Potassium and sodium work has been in progress for over 10 years. There was a brief excursion into mercury and the data gathered was given to industry. NASA then backed out and returned to the K-Na systems.

NASA scientists consider the K-Na area a virgin field and well worth extensive work. Current projects involve small test loops, but materials experts are hoping to get into complete systems. Purity is a huge problem here, and extremely elaborate facilities have been built—for every experiment each bit of apparatus gets more and more complex.

There is a large effort in single crystals. NASA would like to be able to measure impurities down to 0.1-part-per-million. Whisker and fiber metallurgy are under active investigation. Lewis is working in copper impregnated with tungsten fibers. One result of such efforts is the confirmation that strength is not determined by long fibers. Short, disjointed fibers in metal matrixes give the highest strength values.

Tensile and stress rupture experiments with tungsten have resulted in facilities that are almost a research job in themselves. Lewis has one of the country's most complete laboratories for high-temperature physical property work in metals.

This center is also engaged in modifying the vacuum chamber area within a large arc furnace. Researchers hope to explore more fully the vacuum-melt technology by keeping all of the work under vacuum. This aspect of metal refining should lead to ingots of purities unheard of in production-type furnaces.

The huge problem of insulating cryogenic tankage is being attacked at Lewis. Even in the familiar method of using layers of heat-reflecting insulators, there is a problem in arrangement—how close these elements can be to each other is closely related to the wave-length of radiated heat.

The linkage between the layers poses a problem. Anything in the spaces impedes the formation of a vacuum by blocking outgassing. The outgassing time could easily nullify the insulation.

• **Electrical requirements**—Transport processes within thermionic converters is another important materials research area at Lewis. Researchers are trying to lengthen the hot emitter life by introducing chemicals into the gap; these react with the material diffusing off the hot surface and then re-deposit.

One group recently completed an

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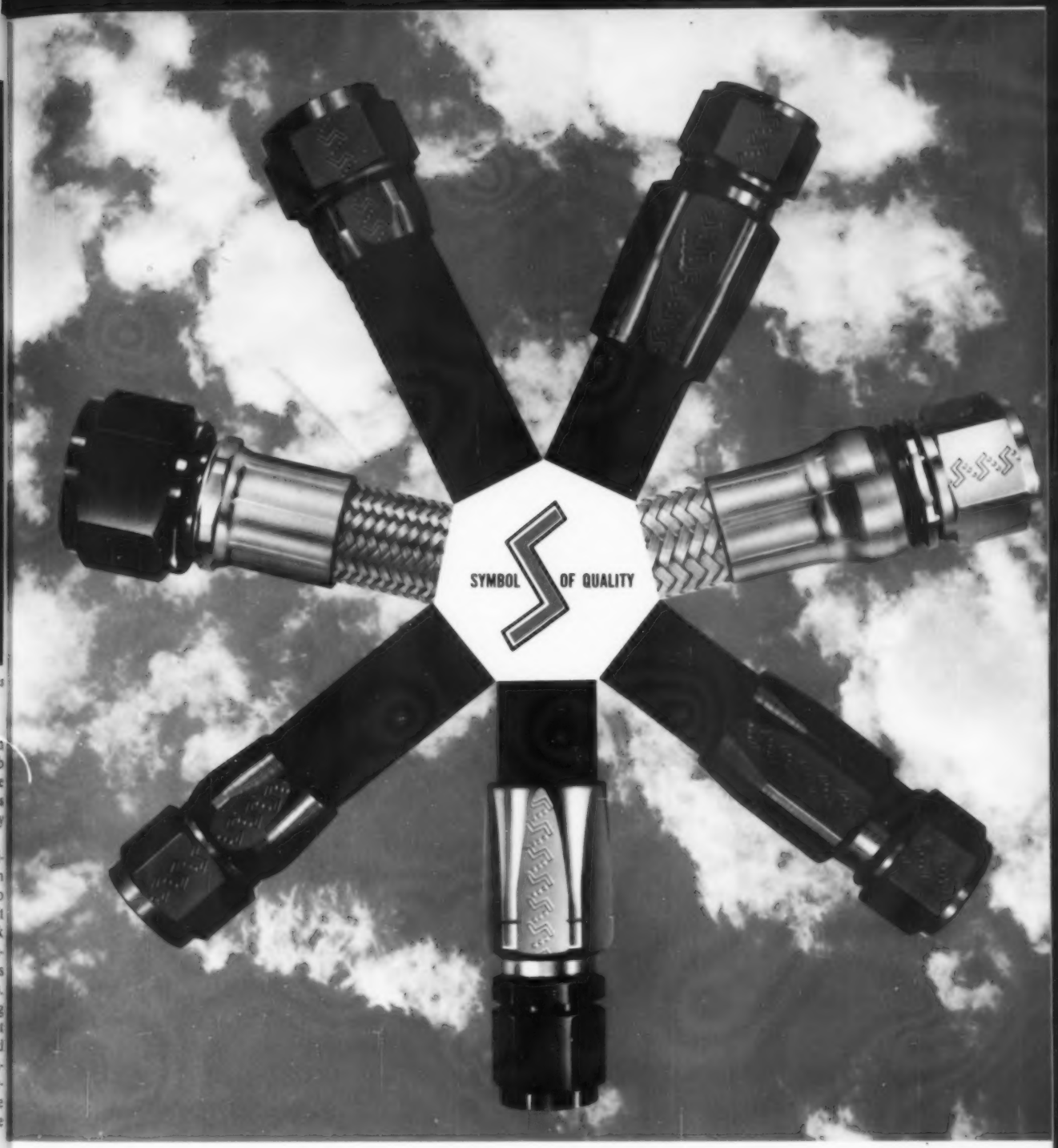

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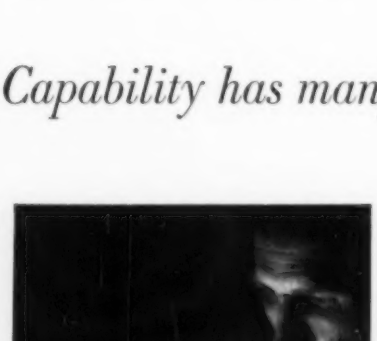
SPACE GLIDER. Drawing of Dyna-Soar space glider, which will combine extreme speed of a ballistic missile with controlled and accurate flight of a manned aircraft. Designed to be rocketed into space, where it could travel at speeds approaching 18,000 mph, Dyna-Soar will be able to re-enter earth's atmosphere and make conventional pilot-controlled landing. Boeing is system contractor for Dyna-Soar, now being developed by U. S. Air Force with cooperation of National Aeronautics and Space Administration.

Capability has many faces at Boeing

THREE-ENGINE JET. Scale model of America's first short-range jetliner, the Boeing 727. Already, 117 Boeing 727s have been ordered by American, Eastern, Lufthansa and United airlines for delivery beginning late in 1963.



PLASMA PHYSICS. Boeing Scientific Research Laboratories scientist has verified experimentally, for the first time, a theory concerning ionized gas — important in future harnessing of thermonuclear power.

AUTOMATIC SKY FIGHTER. Supersonic Boeing Bomarc missile, now operational, is the United States Air Force's push-button defense weapon against airborne missiles and attacking bombers. New Bomarc "B" models have scored test intercepts up to 446 miles from base at altitudes of more than 100,000 feet.

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analysis of radiant heat transfer by integrating the energy across a spectrum of wave lengths, using machine computation. They found answers 25% different from standard gray-body analyses.

There is some work in high-efficiency, high-temperature compounds such as the tellurides and sulfides. Extremely thin-film solar cells are being investigated. Here thinness is determined by molecular thicknesses. The trick seems to be in picking the correct substrate. Lewis is having some success with MgO.

Another project involves spectrally selective surfaces for heat engines. The objective of the search is a surface which will absorb or emit in one end of the spectrum and not the other. If a sharp separation is achieved, an efficient machine will result.

Some interesting problems are cropping up in the cryogenic tankage field. Lewis scientists are currently bursting small vessels in liquid hydrogen. These experimental setups are in themselves a major research and development effort.

Another group has gone deeply into the micrometeorite effect. They are learning exactly what happens to a vessel full or partially full of liquid by firing high-speed particles into test chambers.

In one particular experiment, a particle was fired through an existing hole into a liquid-filled tank. The hole had been sealed with plastic tape. The liquid easily absorbed the projectile's energy, but the shock wave produced in the liquid shattered the tank.

This secondary effect is being explored; higher-speed projectiles, up to 30,000 fps, are being planned.

NASA has specific need to find proper materials for containing liquid potassium and sodium. Lewis is now screening all commercially available alloys. If none fit the bill, the Center will proceed to develop one.

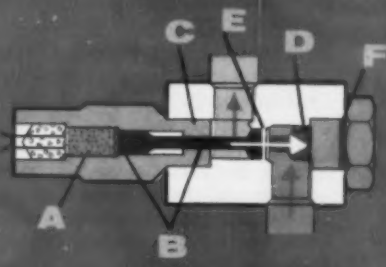
Materials work at Ames is difficult to separate from the re-entry projects under way at the Center. The vast majority of the materials effort is in evaluation or suitability studies involving re-entry simulation.

Some programs are concerned with the reaction of materials to ion bombardment in space—the erosive effect.

Jet Propulsion Laboratory has no demanding in-house materials work at present. Their major concern is in getting the lunar-planetary programs under way. At present, project directors are reluctant to predict or speculate in this area.

Provisions have been made to construct a materials laboratory at JPL to support the lab's space vehicle development responsibility. ⌘

after 5 years of storage life



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NASA SPACE MEDICINE

Panel to Decide How 'Bio' Funds Are Spent

CHART shows need for space medicine investigations by specific categories.

NASA'S SPACE medicine or "bioastronautics" efforts are oriented in two directions. They are under the Office of Aerospace Medicine and the department of Bioscience Programs, in the Office of Space Sciences.

Aerospace Medicine has headquarters at NASA's Washington offices and will have some facilities at the Manned Spaceflight Center at Houston. Bioscience Programs is located at Ames Research Center, Moffett Field, Calif.

However, the entire NASA life sciences operation is now facing one of the most crucial periods in its rather harried existence. A bioastronautics panel, chartered by the National Aeronautics and Space Council, is currently investigating all space medicine facilities, military and civilian, to determine whether duplication exists, precisely what new facilities are needed—and who should build them.

The Bioastronautics Panel is believed to have been initiated because of the many accusations of "wasteful spending" and "empire building" leveled at the NASA office of life sciences since its inception in spring, 1960. Congressional committees have constantly questioned the necessity of constructing new space medicine facilities when the Air Force appears to be so well equipped.

Dr. Edward C. Welsh, NASC executive secretary, has indicated that when the panel, comprised of some 10 educators, reports its findings, a recommendation will be made which will generally determine the future of NASA's space medicine programs.

If the panel finds military installations adequate for space medicine research, as many of NASA's critics in Congress hold, NASA may find its programs limited to the more or less "basic" research for which a capability is rapidly being built at Ames. If the military installations are found lacking, NASA will undoubtedly get a full-steam go-ahead and sole responsibility for the problems of man-in-space, including sole responsibility for all bio-satellite shots of any kind.

• **Budget breakdown**—NASA's original '62 space medicine budget request was for $8.6 million. The authorization was upped to $20.6 million upon the Administrations's decision for the manned lunar program. Of this $20.6 million, $5.3 million will go to aerospace medicine research and $4.1 million to advanced technical development in aerospace medicine—all the responsibility of Brig. Gen. Charles H. Roadman.

Space biology, whose chief is yet to be named, has been appropriated $1.8 million for research and for technical development. For both programs, a fund of $9.4 million exists for flight experiments.

• **Space biology**—Broad objectives stated for space biology are: 1) study effects of space environment on living organisms, 2) assess organic chemical life-supporting compounds on extraterrestrial sites, 3) develop means of remote identification and analysis of possible extraterrestrial life forms, 4) prevent terrestrial organic, chemical or microbiological contamination of extraterrestrial bodies to preserve them for study of life processes.

The future of the Ames Research Center seems fairly certain. The center is developing considerable in-house capability for biological probes as well as ground simulation facilities. At present, there are about 20 of a proposed 100-man technical staff, many of whom were transferred from NASA headquarters. One of these men is employed full time for procurement, indicating expansion potential.

Ames also has budgeted $5.7 million under construction of facilities. Of this, $800,000 will be used to modify and equip part of the flight operations laboratory for a life science research facility. This operation will enable the life science group to study some of the biotechnological aspects of spaceflight and do basic research in space medicine.

• **Ames shopping list**—The center already has a battery of simulators, some left over from NACA days. However, it is aiming for a space chamber-type simulator which can be used in conjunction with its movement simulators. This might have five degrees of motion in a chamber with heat, pressure, oxygen environment, isolation, and noise controls, etc. Ames has also stated a desire for a device to simulate a 14-day space trip, but in view of the prohibitive costs, it is not likely to be on the shopping list soon.

The Ames group is studying various restraint systems. It has, in fact, designed one for research programs aimed at determining the ability of pilots to perform meaningful control tasks during high accelerations . The Ames group uses the Southern California and Johnsville centrifuges to test these systems. Much of the restraint suit work is done in-house, but some of the work went to industry, such as a helmet which was designed by Protection Inc., of Los Angeles. It is expected that other projects of this type will be forthcoming.

Bioinstrumentation for measuring pilot response during centrifuge tests and weightlessness experiments (in fact, all simulation devices) may provide a market for industry devices. Hughes

Aircraft Co., for example, was the recent recipient of a $75,000 contract for a physiological monitoring system for the *X-15*.

The biosciences group also plans to develop a primate training facility for laboratory research and experimental flight. Equipment needs may include animal training devices, environmental chambers and life support systems suitable for flight.

NASA also lets contracts for basic research experiments which may have space on space vehicles. An example is the *BIOS I* shot (Biological Investigations in Outer Space) which carried experiments designed by universities, AEC laboratories and industry. These awards usually are in the form of grants, given to groups with a known or demonstrated capability in a certain type of research.

More and more contracts undoubtedly will be awarded for space capsules to carry biological probes. These probes require intricate electronic devices, timers, actuators, etc., to conduct rather complicated experiments enroute. As an example, General Electric got $523,000 to modify the *Nerv* capsule for the *BIOS* experiments.

NASA will support work in the categories of experiments in radiobiology, microbiology, meteorite analysis and extraterrestrial environmental studies.

The technical development authorization is planned to go for decontamination techniques, microbiologic analysis, chemical analysis and instrumentation.

• **Space medicine**—Aerospace medicine's broad objectives are: 1) Finding requirements for integrating the human operator into space systems, 2) perfection of life support systems, 3) determining best methods of giving information to human pilots, 4) protection of man and machine against radiation, 5) biological aspects of communications, 6) remote control, 7) bioinstrumentation and 8) space crew selection and training.

Inflight experiments to support the aerospace medicine program will be concerned with weightlessness, radiation and flight testing of components and medical systems.

The money appropriated for advanced technical development will roughly go to development of radiation protection, protective life support systems, displays, controls, models and simulators for crew selection and training.

NASA aerospace medicine officials have expressed a desire to develop flight vehicles for investigation of space radiation, weightlessness and the search for extraterrestrial life. They wish to perfect a recoverable biosatellite for primate and lower biological systems, and spacecraft laboratories carrying men, which would orbit under the radiation belts to investigate weightlessness. Life support systems and subsystems for these craft will ultimately be necessary.

NASA's Manned Spaceflight Facility at Houston will include a section for Aerospace Medicine. This operation, according to officials, will not be involved in basic research for manned spaceflight. Rather, it will be concerned with the development of specific life support systems, space suits, etc., and the selection and crew training for actual flight.

This operation will require many expensive training devices, such as simulators and a centrifuge. Just how much money the facility will actually be given for equipment will depend largely upon the Bioastronautics Panel's findings. *Apollo* astronauts may be forced to travel about the country to use existing military equipment, as did the *Mercury* astronauts, if the Panel decides present facilities will suffice. ⁂

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Agency Preparing to Award as Much a

While retaining for the present its established types of contracts, NASA will add procurement personnel, revise procedures, possibly delegate more authority to field centers

NASA contracting with U.S. industry over the next several years will approach and perhaps surpass $4 billion annually.

To gear up for this giant procurement effort, the space agency is beefing up its procurement staffs, trying to attract more firms to its industry team, and making some changes in its contracting procedures.

Two things appear certain, however:

—There will be no major changes in the types of contracts awarded by NASA—at least for the next couple of years.

—Advertising for bids which includes asking for industry proposals to bid will continue to outstrip negotiated contracts.

While the main elements of NASA contracting policy will remain the same, the agency is making some innovations and refinements in procedures. These include:

—NASA headquarters may delegate more authority to the field centers, where almost all of the agency's contracting is done. Currently, headquarters must approve all contracts over $100,000 at all centers except Marshall Space Flight Center. Marshall can award contracts up to $1 million without approval. This is currently under review. One center — the Manned Spacecraft Center at Houston—is almost certain to get more authority.

—A major effort will be made to insist that firms submit complete, accurate and current cost data during contract negotiations.

—To make better use of DOD audit services at missile/space industry plants, NASA is assigning its own representatives to plants with major NASA contracts, to supply liaison between the contractor and the space agency.

—A review of contracting procedures at field centers is being undertaken by teams of headquarters procurement officers. Its major effort will be to streamline and standardize contracting policies.

—Better reporting systems are being developed. Center procurement offices will be required to submit status reports on all contracts over $100,000.

• **How it slices**—The estimate of the total size of NASA procurement is based on NASA's experience in Fiscal 1961 and its estimate for the current fiscal year.

Of NASA's total Fiscal '62 budget of $1.672 billion, some 80%, or $1.3 billion, will go to U.S. business. Some 56%, or $750 million, will be awarded in direct contracts to industry.

About 15%, or $200 million, will go to non-profit corporations including the Jet Propulsion Laboratory; another 29%, or $389 million, will go to other government agencies. NASA officials said, however, that almost all of the funds going to the non-profits and Federal agencies will—in turn—go to industry in the form of contracts.

With NASA's total budget expected to hit $5 billion annually in the near future, it is likely that the portion going to industry will approach $4 billion and will continue at that rate or surpass it for quite a few years.

Firms participating in this giant procurement program will find that NASA has two basic contracts which account for almost all of its procurement.

• **Fixed-price contract** — This is used most frequently and is preferred for procurement of goods and services that can be clearly described. This type of contract can be used for either formally advertised bids or for negotiated procurement. There are also occasions when a fixed-price or "lump sum" contract may be employed to support research.

In arranging a fixed-price contract, provision may be made for special situations. As an example, it could be used for price redetermination when the performance of the contract may involve large contingencies or uncertainties in cost, such as first-time production runs.

• **Cost-type contract**—This usually involves the payment of the total costs of the project plus a certain fixed fee. While fixed-price contracts are the most frequent, the cost type of contract accounts for a larger dollar share of NASA's total procurement.

This type of contract is used when there are a number of unknowns in a program, as in research and development. For example, NASA may use a cost-type contract to support either basic or applied research which has a fixed objective and a deadline for completion. A cost-type contract would—in such circumstances—protect a firm from assuming unwarranted financial risks due to technical uncertainties. Compensation for taking on this type of work could be either straight reimbursement or reimbursement plus an agreed upon "fixed fee." The law prohibits any government agency from entering into any contract which calls for reimburstment of cost plus a percentage of cost.

NASA would very much like to place greater emphasis on the cost-plus-incentive-fee contract, but this is out for the next couple of years. The agency recently conducted an in-house review of this concept, but its procurement officials have decided that implementation to any great degree is impossible at this time.

The big problem in this area is that a lot of "cost experience" is required in order to assess contract performance on which the incentive fee is based. Because most of NASA contracting in the R&D field involves state-of-the-art advances, use of the incentive fee would create real difficulties in contract negotiations and administration.

• **Procedures**—Firms wishing to do business with NASA should be aware of the following documents:

—*Selling to NASA*—published by NASA headquarters, this booklet includes a complete rundown on contracting procedures.

—*Standard Form 129*—This form

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must be filled out before most manufacturing firms can be placed on the bidders list to which all "proposals to bid" are sent.

—*Form 1071*—This form is for the use of architectural and engineering firms and also puts these firms on the contract bidders mailing list.

Firm included on the bidder lists receive invitations to bid which include technical specifications, delivery or completion dates, place and methods of delivery, the nature and number of reports or manuals which may be required, and other items which should be considered in submitting a bid.

Firms do not have to wait for NASA to make a formal request for an R&D proposal. There is no specific form for unsolicited proposals, but some of the information which it should contain includes:

—Name and address of the organization.

—Number of employees, including totals and qualifications for technical personnel.

—Brief description of facilities, outline of previous work, and a brochure and financial statement, if available.

—Title of proposed research and the name of the principal investigator.

—A brief abstract of the proposed project and a suggestion as to starting and completion dates.

—An outline of the proposed budget and costs.

• **For small business**—NASA also has a program designed to increase opportunities for small business firms to take part in U.S. space program.

Most of these opportunities lie in subcontracting work with NASA's prime contractors.

To insure that small business firms are being given an equal opportunity to share in the space business, NASA requires that all prime contractors and all subcontractors with awards over $1 million participate in the program.

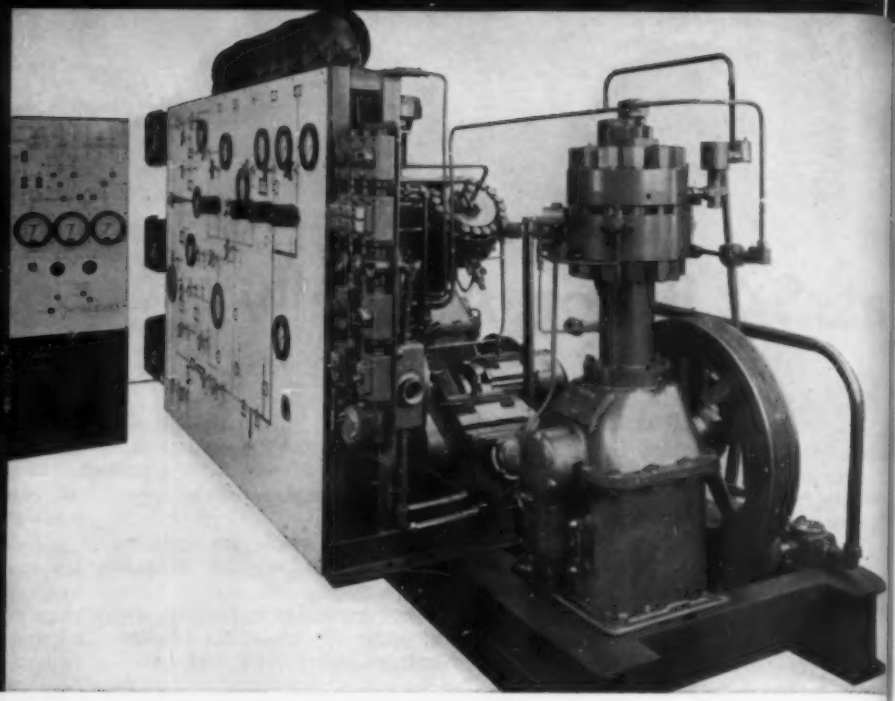
It requires that these firms appoint a small business liaison officer who must work with officials of both the Small Business Administration and NASA.

The liaison man must set up a program to insure that small companies have an opportunity to compete with big firms, and he must keep records and report how much of the work is going to small firms. ⌗

Directory of NASA Procurement Organization

Center	Address	Contracting Areas	Procurement Chief	Small Business Advisor
NASA Headquarters	*Washington 25, D.C.*	*Overall Management and Administration of Agency Contracting Procedures*	*Ernest W. Brackett, Director*	*Jacob M. Rooy*
Headquarters Procurement Branch	*Washington 25, D.C.*	*R&D Study Contracts Supplies*	*Alebrt A. Clagett*	*None*
Ames	*Moffett Field, Calif.*	*Life Sciences—Simulation Electronics and Electrical Devices*	*A. S. Hertzog*	*Donald E. Davis*
Langley	*Langley Field, Va.*	*Electronics, Optics, Simulation*	*Sherwood L. Butler*	*Joseph F. Braig*
Goddard	*Greenbelt, Md.*	*Spacecraft, Scientific Instrumentation, Batteries, Tracking and Computing Equipment, Environmental Chambers—Battery R&D, Data Handling Services*	*Gordon H. Tyler*	*Harry T. O'Toole*
Jet Propulsion Lab. Western Operations	*Pasadena, Calif. Santa Monica, Calif.*	*Scientific Instrumentation, Spacecraft Tracking Manager and Monitor Contracts For West Coast NASA Installations*	*Ted Candee Earle Sample*	*D. W. Anawald Paul E. Ross*
Flight Research	*Edwards, Calif.*	*Only Small Procurement in Support of X-15 and Apollo Re-entry Research*	*Morris E. Bowling*	*Lloyd J. Walsh*
Wallops	*Wallops Island, Va.*	*Electronics Subsystems and Range Services*	*Louis T. Birch*	*Joseph Robbins*
Marshall	*Huntsville, Ala.*	*Saturn & Centaur Procurement, RIFT, J-2 Upper Stage*	*Wilbur S. Davis*	*Wm. C. Sayre*
Lewis	*Cleveland, Ohio*	*Electrical Propulsion and Apollo Spacecraft Propulsion Segments*	*John Biggs*	*Norman C. Prahst*
Launch Operations Directorate	*Titusville, Fla.*	*GSE, Electrical Components, Cryogenics*	*Gerard A. Michaud*	*None*
Manned Spacecraft Center	*Houston, Tex.*	*Spacecraft, Electronics, Life Sciences, Instrumentation*	*David W. Lang, Jr.*	*Harold Christian*
Space Nuclear Propulsion Off.	*Germantown, Md.*	*Nuclear Propulsion*	*L. C. Corrington*	*None*

planning a SHOCK TUBE facility?



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Illustrated above is a shock tube pressurization system recently constructed by Aminco for a major aircraft company. The system is designed for pressurization of a large 15,000 p.s.i. system. It includes three Corblin diaphragm-type compressors (two shown); manual and automatic controls for pressurization and firing of the shock tube; a medium-pressure gas-mixing vessel (not shown); and a high-pressure gas-storage vessel (not shown).

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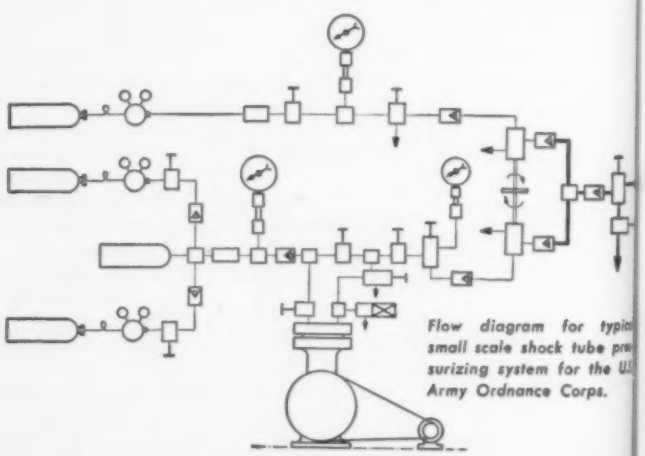

Flow diagram for typica small scale shock tube pres surizing system for the U.S. Army Ordnance Corps.

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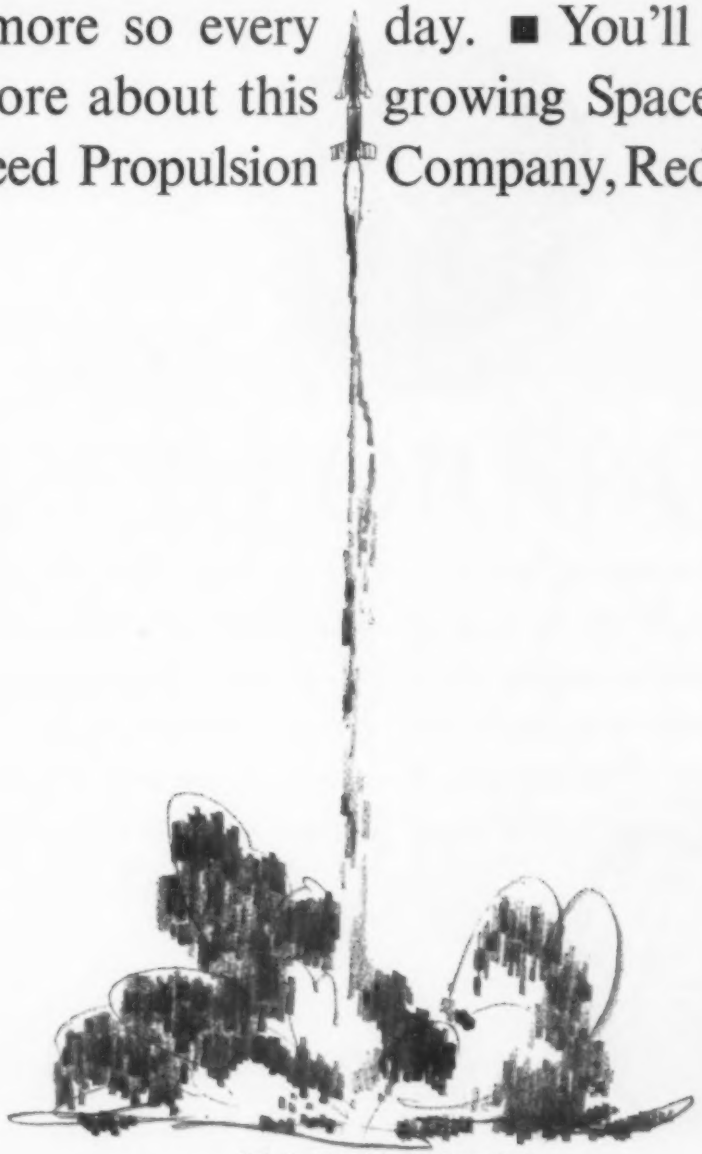

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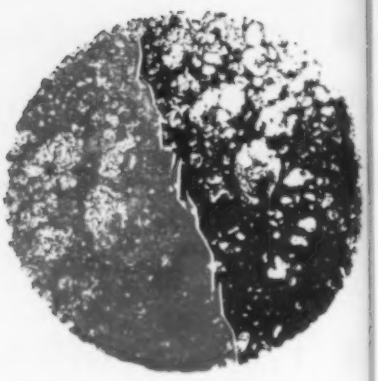

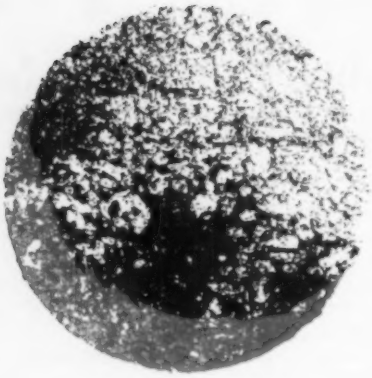

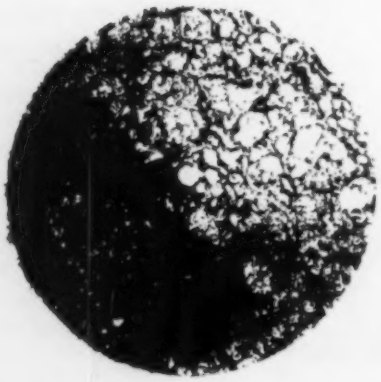

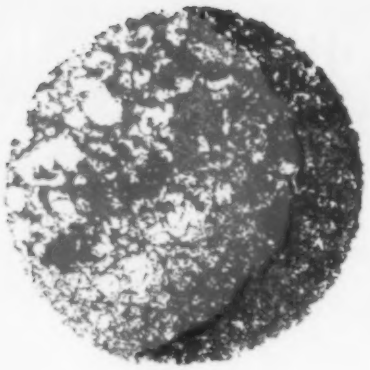

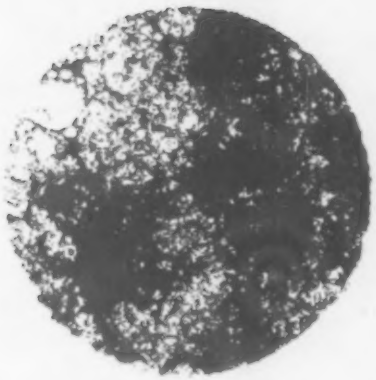

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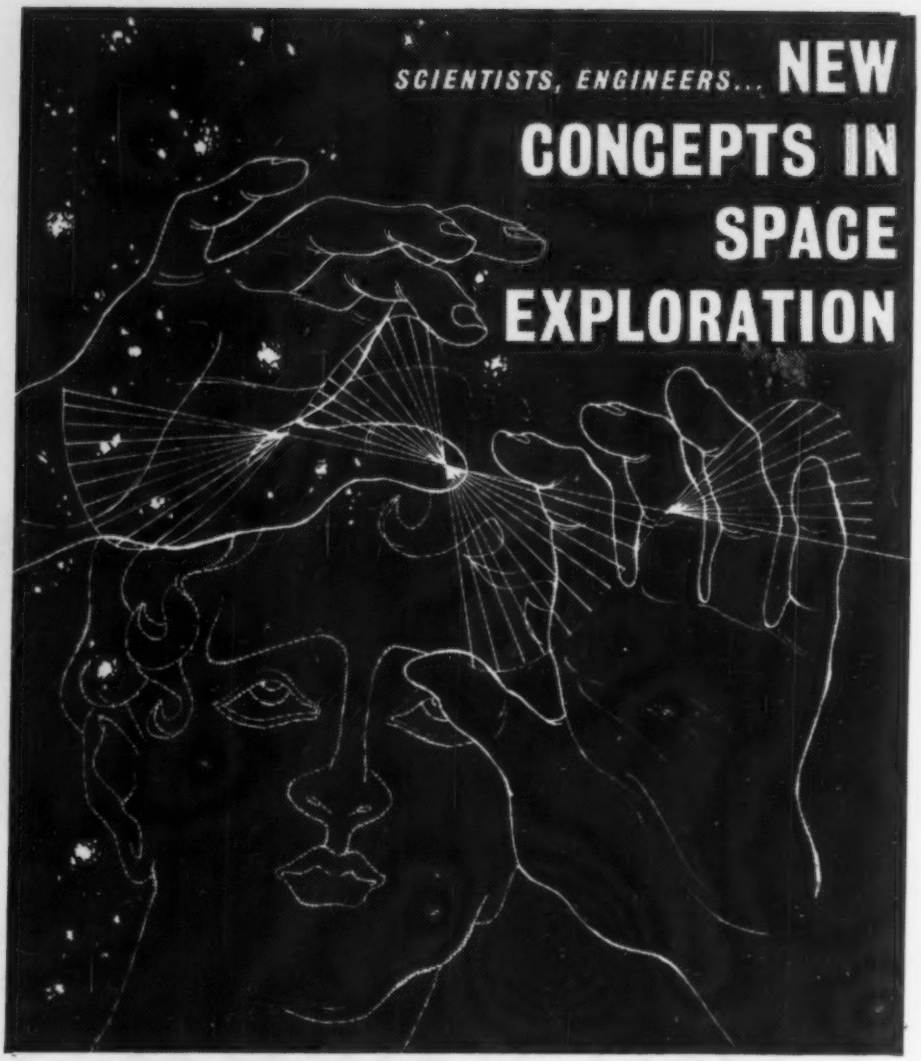

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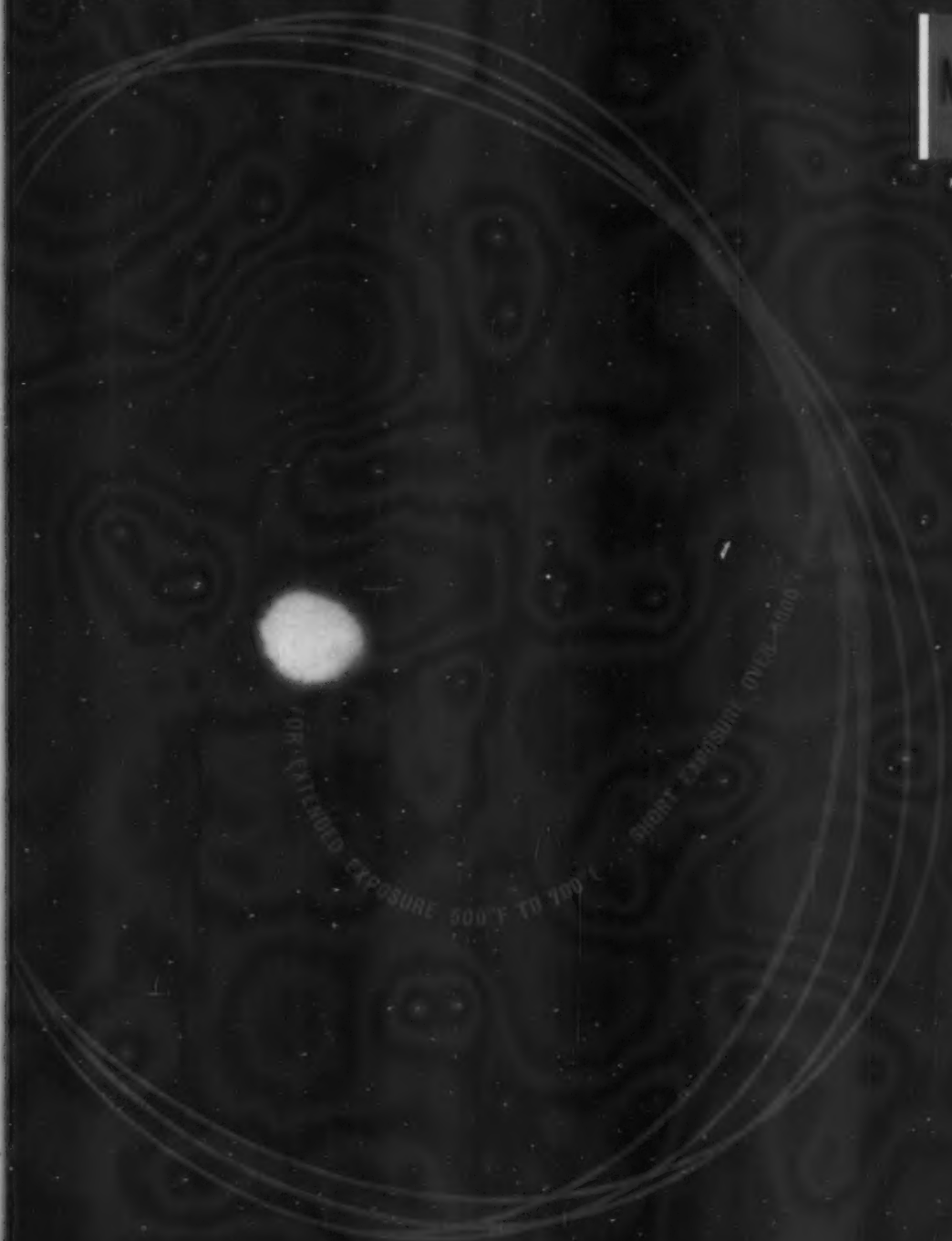

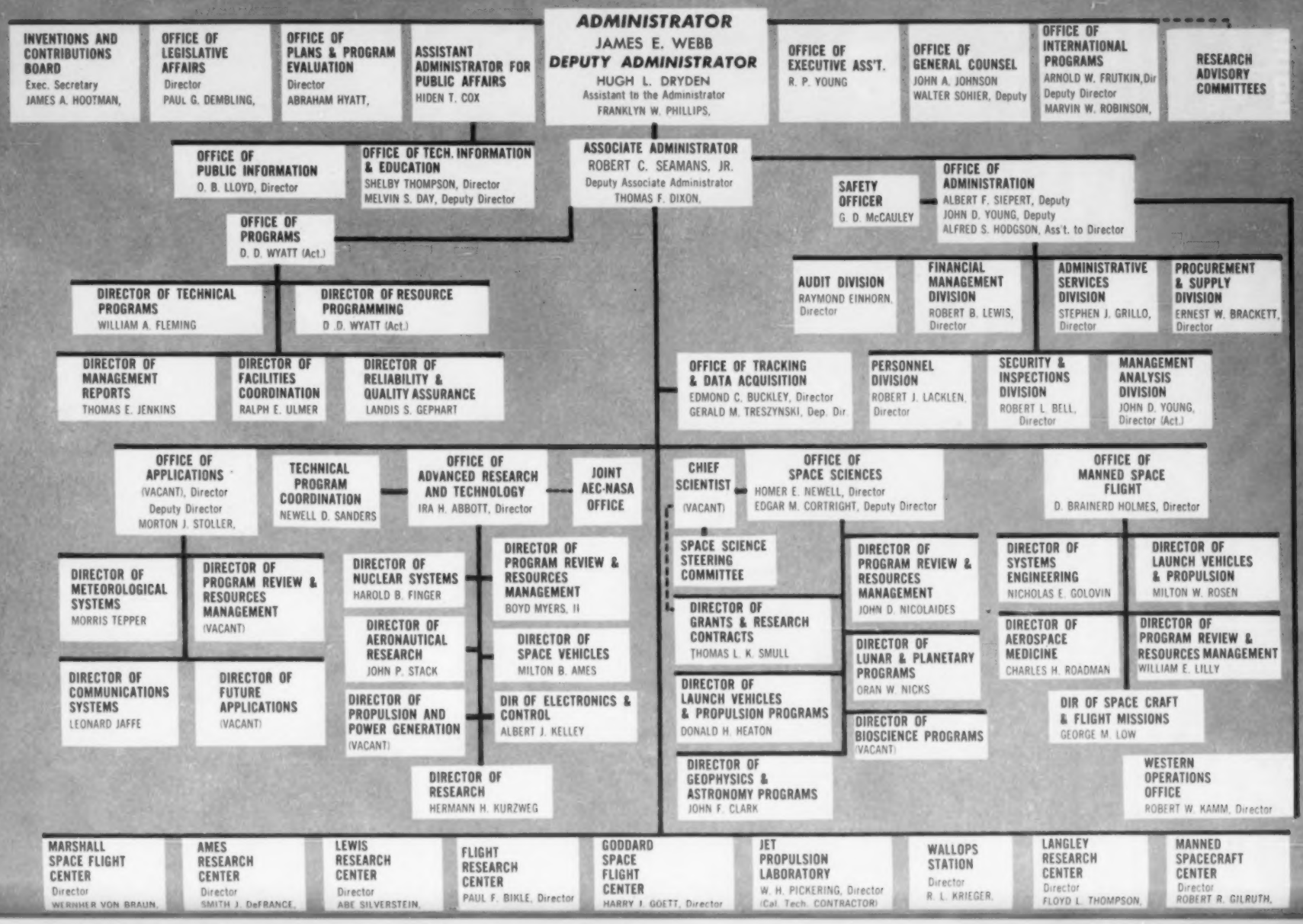
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Seamans Runs 24,000-Man Lunar Team

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Apollo's Key Strategists Are Now Welding Together Vast Government-Industry Complex

NASA's management team for the *Apollo* program will utilize the skills of some 24,000 individuals under the direction of one man—Associate Administrator Robert C. Seamans, Jr.

He will give final approval for funding of the program, launch schedules and firing dates, program objectives and its completion date.

Other important members of the space agency's new management concept will be the directors of the four major program offices in headquarters and the directors of NASA's various field centers.

The program directors will determine the resource and funding needs of their programs and lay work on the centers. The directors of the field installations will have direct access to Dr. Seamans and will be involved in future policy and program planning.

For the *Apollo* program, primary roles will be played by the Marshall Flight Center, for launch vehicle development, and the Manned Spacecraft Center, for the *Apollo* spacecraft. Overall management control will be in the hands of D. Brainerd Holmes, director of the Office of Manned Space Flight Programs.

NASA officials estimate that the *Apollo* program will consume well over one half of all the space agency's appropriated funds through 1970. About 90% of this will be split about equally between Marshall and Houston.

The remainder will pay the costs of supporting missions at almost all other NASA centers—with main emphasis on the Jet Propulsion Laboratory, Ames Research Center, Lewis Research Center, Langley Research Center, Goddard Space Flight Center and Edwards Flight Research Center.

• **Final lineup**—Final details of NASA's beef-up and reorganization to gird for the long road to the manned lunar landing were released recently as the space agency moved closer to major contract awards for both the spacecraft and its launch vehicle.

Dr. Seamans will serve as its general manager and as arbiter of major disagreements between his management chief, Holmes, and the heads of the various field centers.

He will make the final decision in any matter involving a change in funding or schedule for the program. He will also serve in the same capacity for programs falling under the other three major NASA program offices—Applications, Advanced Research and Technology, and Space Sciences.

He will have as his chief assistants Deputy Associate Administrator Thomas F. Dixon, D. D. Wyatt, Director of the Office of Programs, and Albert P. Siepert, director of the Office of Administration.

The latter will deal with financial reports, contracting and administrative services. Wyatt's office will be responsible for coordinating the budget requests of the centers and the various program offices.

• **PERT plus PDP**—To keep track of the program and to channel information from contractors and the field centers to NASA headquarters, the space agency is incorporating two management control techniques — Program Evaluation and Review Techniques (PERT) and the Project Development Plan.

The PDP will be prepared by the director of the field center having major responsibility in the program. It will include program justification, history, scheduling, organization and estimates of needed management, technical resources, funding, and organization.

These will then be sent to the appropriate headquarters program office to be evaluated, revised and endorsed for Dr. Seamans' approval.

PERT—the computer management technique—will be used to keep track of the program, insuring that there are no bottlenecks and that its schedule will be met.

Estimated NASA Fiscal 1962 Employment Total

	Approved Complement 6/30/62	Current on-board 10/15/61	New Positions
Headquarters	1,403	805	598
Langley	3,628	3,366	262
Ames (including Life Sciences)	1,675	1,513	162
Lewis	3,608	2,891	717
Edwards Flight Research Center	494	468	26
Goddard	2,360	1,672	638
Manned Spacecraft Center (Houston)	1,640	981	659
Wallops	399	364	35
• Marshall	6,490	5,734	756
Western Operations Office	119	70	49
Nuclear Office, Cleveland	28	16	12
Agency Total*	21,844	17,880	3,914

• Includes Cape Canaveral and Pacific Missile Range Personnel.

* Does not include Jet Propulsion Laboratory Total.

PERT is now being used on the *Nimbus* meteorological satellite and the *Syncom* communications satellite programs. It will not, however, be completely implemented in the NASA operation for another year.

Both tools will be used by Holmes, who will be in direct management control of the *Apollo* program. While many of the top decisions will have to be approved by Seamans, the associate administrator declares that "he (Holmes) will be given all the authority to get the job done."

In his job as Director of the Office of Manned Space Flight, he will recommend to Seamans:

—The programs needed to achieve a manned lunar landing.

—Needed action on Project Development Plans prepared by the Centers.

—Estimates of funds required for the *Apollo* program.

—Advanced research and technical development activities which are needed.

In his relations with the Centers, he will:

—Establish and issue instructions in the technical execution of approved projects.

—Authorize the spending of all program-related funds.

—Review and approve basic changes in schedule and reprogram resources.

If budget limitations or schedule dates are affected, final approval must come from Seamans.

—Resolve technical and management disputes between centers.

He will also evaluate the program and project progress and make interpretative status reports of any deficiencies and recommendations for corrective action to Seamans.

• **Joint policy-making**—The directors of the field centers will also play an important role in policy formulation. For the *Apollo* program, this will accrue to Dr. Wernher von Braun at Marshall and Robert R. Gilruth at the Manned Spacecraft Center.

They will take part in both short- and long-range program planning. NASA is presently considering ways of best implementing the new policy. One idea would bring directors of all of the centers to Washington or a central location for regular—perhaps monthly—meetings with the headquarters program directors. Another would involve regular meetings between the program and center directors involved in a specific program.

The heads of the centers will also report directly to Seamans on their budget and personnel requirements.

In cases where they feel that missions and work laid on the center by the program director would overtax its facilities, they will have the right to appeal to Seamans. These appeals will not be encouraged by Seamans, however, and will be permitted only under exceptional situations.

To speed the flow of information from the field centers to headquarters, the following reports will be required:

—The Project Status Report—requirements for this will be set by each headquarters program office.

—Project Management Reports (bi-weekly).

—PERT Report—Required bi-weekly for inputs into the space agency's overall program control setup.

—Contractor Financial Report—Contractors will be required to report costs, manpower costs, or all systems and subsystems. This will be used by both program and center director.

—Procurement Status Report—Milestones in each procurement action will have to be set and reports of progress toward them made to headquarters.

—Procurement Action Report—All new contract obligations over $25,000 will be reported to headquarters. ■

Major NASA Spacecraft and Satellite Programs

MERCURY (Houston) First manned orbital shot early '62; first U.S. manned satellite program. Three-orbit mission.

MERCURY IIA (Houston) First flight late '62 or early '63; Mercury with 18-orbit missions.

MERCURY IIB (Houston) No schedule to date; proposed program for two-man capsule capable of two-week orbits.

APOLLO SPACECRAFT (Houston) Boilerplate launching '63; earth orbit '64-'65; lunar landing '67.

TIROS (Goddard) First launching April, '60; second, Nov. '60; third, July '61. Weather satellite with TV cameras and IR scanner. Four more flights planned.

NIMBUS (Goddard) First launch late '62; second-generation, earth-stabilized, polar-orbiting weather satellite. Four launches planned.

AEROS (Goddard) First flight '65-'66; synchronous orbiting weather satellite.

ECHO (Goddard) First launching '60; second, '62; passive communications satellite, rigid sphere.

REBOUND (Goddard) First flights late '63-'64; passive communications satellite similar to ECHO; three-six planned.

RELAY (Goddard) First flight '62; active repeater communications satellite; similar programs under R&D by AT&T (TELESTAR) and the Army (ADVENT).

SYNCOM (Goddard) First flight late '62; 24-hour instantaneous repeater satellite.

RANGER (JPL) First flight Aug. '61 failed; second late this year; first lunar landing mid-'62. Instrumented capsule to be rough-landed on moon; early flights in earth orbit.

SURVEYOR (JPL) First lunar flight '63; designed for soft-landing on moon with 100-300 lbs. of instruments.

PROSPECTOR (JPL) No schedule to date; remote-control, soft-landed lunar exploration vehicle; may be tied to Manned Lunar Landing Program.

MARINER/VOYAGER (JPL) Venus fly-by Aug. '62; Unmanned spacecraft for early planetary exploration.

ORBITING ASTRONOMICAL OBSERVATORY-OAO (Goddard) First flight late '63-early '64; 3500-lb. "streetcar" satellite equipped with telescope.

ORBITING GEOPHYSCAL OBSERVATORY-OGO (Goddard) First flight '62; 1000-lb. satellite with instruments for geophysical measurements; polar-orbiter called POGO; eccentric-orbiter, EGO.

ORBITING SOLAR OBSERVATORY-OSO (Goddard) First flight late this year; second, '62; satellite for observation of sun and solar atmosphere.

MARSHALL CHIEF Wernher von Braun, with members of his "team," maps expansion schedules.

NASA INDUSTRY GUIDE

Marshall to Get $1 Billion in '63

THE HISTORIC Marshall Space Flight Center—largest and richest of NASA's centers—is undergoing a new explosion of growth in personnel, facilities and pocketbook.

The sprawling research center at Huntsville, Ala., which in its days as an Army installation hurled America's first satellite around the earth, looks today like an overnight boomtown.

New facilities and additions to old ones are going up in almost every direction a visitor looks in the welter of buildings spread out on the flat, red Alabama clay.

The center's original 1200 acres have been extended by another 120 to make room at its heart for a new $4-million Central Laboratory and Headquarters Building. Meantime, temporary office space has been rented in various nearby buildings including two former motels and a restaurant.

The Marshall Procurement Office, currently letting contracts at a total rate of about $600 million a year, is operating out of the former Twickenham Hotel in downtown Huntsville. The hotel's former registration desk is manned by a uniformed security guard.

Marshall's role as the NASA center responsible for the development, production and launching of large space boosters and their upper stages has assured it a pivotal place in the Manned Lunar Landing Program.

• **Wealth of programs**—The center—under the direction of Dr. Wernher von Braun, and still for the most part his famed "team"—is currently in charge of programs for boosters and upper stages ranging from the *Nova* and the *F-1* and the *Saturn* to the 15,000-lb.-thrust RL-10A-3.

Among Marshall's other programs are *Centaur, the* 200,000-pound-thrust *J-2*, the *RIFT* nuclear rocket, the design of ground support equipment, electric propulsion, and advanced liquid- and solid-propellant technology.

To support these operations, Marshall received $756.7 million for FY '62—nearly double its budget for FY '61. And the new FY '63 budget for the center is expected to rise to about $1 billion—nearly a third of the budget for all of NASA.

Nor is this anywhere near a peak. Within the next several years, the Marshall budget is expected to more than double again. NASA officials currently estimate that about 50% of all funding for the Manned Lunar Landing Program will be funneled through Marshall.

The general breakdown on where Marshall is spending its money in the current fiscal year: $562.7 million for R&D, $123.4 million for construction of facilities at Marshall and around the country and $70.5 million for salaries and expenses.

Some of the increases in FY '63 will be spent for additional personnel and facilities, but the bulk is expected to be applied under the R&D account. One of the major new items to be added to R&D spending will be the production of *Saturn* boosters at the newly acquired Michoud Arsenal in Louisiana.

Marshall plans to let contracts before the end of the year for production of both the *Saturn S-1* and *S-1B* at the $50-million Michoud plant. These production programs are expected to run to a total of more than $2 billion.

An interesting sidelight to the Michoud operation is the current heavy competition for the plant housekeeping contract. More than 40 bidders, including a number of major missile/space corporations, are fighting for it.

Another new major addition to Marshall's procurement operations within the next few months will be the *RIFT* program.

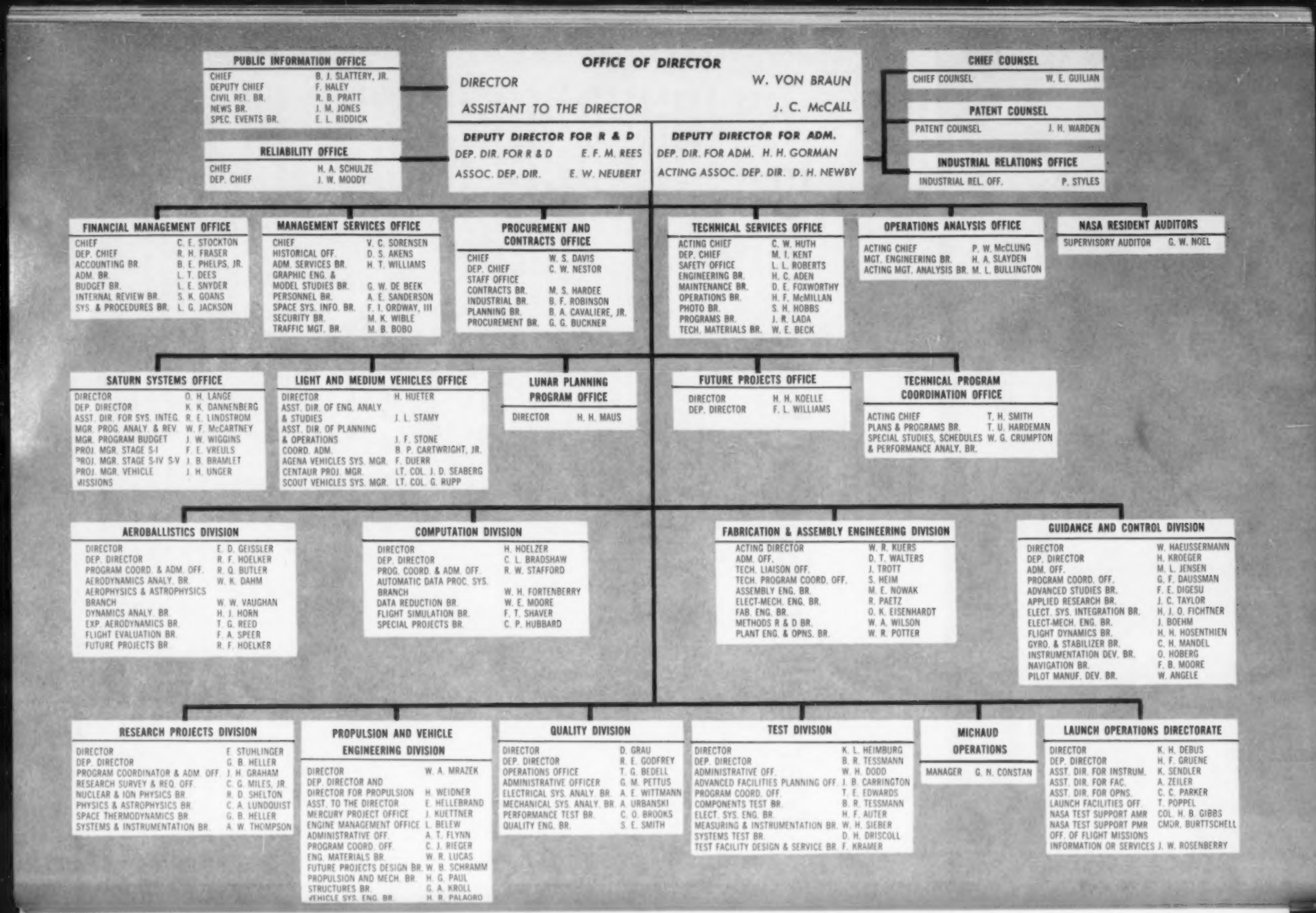
• **R&D slices**—During the current fiscal year, the bulk of Marshall's R&D budget is for *Saturn, Nova, Centaur* and the general liquid-propulsion program, which is mainly the *F-1* and *J-2* engines.

Here is the breakdown:

Saturn—$224.1 million (including $3 million for the RL-10 engine, $3 million for *J-2* flight hardware and $13.3 million for GSE).

Nova—$48.5 million (including $40 million for vehicle development, $6.5 million for engine development and $2 million for system support). This funding is subject to sharp adjustment in

(Text continues on page 91. On page 88 is a Marshall organizational chart.)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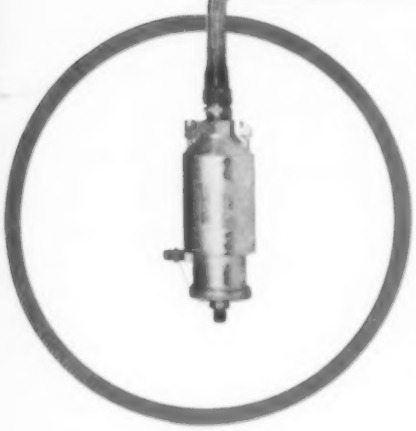
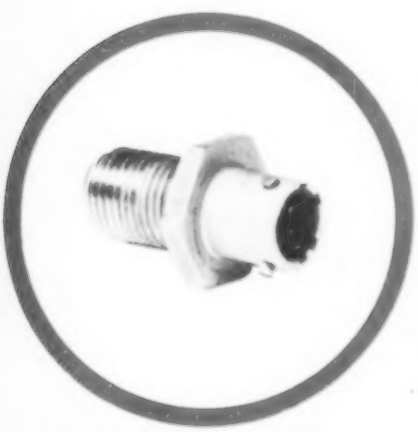


FLEXIBILITY of McCormick-Selph explosive ordnance products is exemplified in the COOL GAS GENERATOR (at left). Greater compactness, lighter weight and ease of storage provide many inflatable bag system applications for: flotation, jacking, ejection, gas supported structures, forming; as well as potential applications such as power supplies for driving turbines, gas motors, pistons, fluids; pressurization of fuel tanks.

GREATER SAFETY of McCormick-Selph units is demonstrated in the XBS Modular Exploding Bridgewire System (at right). Developed in conjunction with the Industrial Products Div. of ITT, the system eliminates the use of sensitive primary explosives, and as a result is insensitive to all ordinary physical and electrical shocks, including RF energy, that could cause inadvertent firing.

EXPLOSIVE ORDNANCE

to ignite to detonate to actuate to eject to open to close to pull to push to inflate to stabilize to release to start to stop



VERSATILITY is a maxim at McCormick-Selph. A typical by-product of this versatility in research, design, and production is the welded seal M-100 all-purpose, STAINLESS STEEL PRESSURE CARTRIDGE (at left). Its versatility is not only its environmental compatibility characteristics, but its multi-use applications. This unit develops 200 psi (in a 10 cc chamber) in 5 milliseconds — sustains 1000 psi for 1 second to do a myriad of functions.

RELIABILITY of McCormick-Selph explosive ordnance components is illustrated in the EXPLODING BOLT (at right). From the first ceramic-to-metal, sealed, screw-in ordnance power cartridge — through 10 years of production of hundreds of varieties of fragmenting and non-fragmenting bolts — McCormick-Selph has developed the experience and quality control methods so essential to the reproducibility demanded in explosive ordnance.

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Use the tear-out information card at right to find out more about our capabilities and products.

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- ☐ Cool Gas Generators
- ☐ Hot Gas Generators
- ☐ Pressure Terminals
- ☐ XBS (Exploding Bridgewire Systems)
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small rocket motors / igniters
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(Continued from page 87)

line with changes in the overall national booster program.

Centaur—$56.4 million.

Liquid Propulsion—$93 million (including $57.3 million for the *F-1*, $28.7 million for the *J-2* and $7 million for advanced systems and components).

• **Staff growth**—Marshall's present total payroll stands at about 5750 people—an increase of about 250 over the approved level for FY '61. The center's present plans call for adding about 750 additional people by next spring, bringing the total payroll to more than 6500.

This increase is more than 400 fewer than NASA originally estimated in its revised budget last spring. However, even at 6500 Marshall will be nearly twice the size of the second largest NASA center—Langley.

Expansion of Marshall over the next several years is expected to push the payroll to more than 8000, possibly 9000 at the most. Any increase beyond this would be opposed by the center's top officials.

"We don't want to go to 10,000 and 15,000 and 20,000 people," Dr. Eberhard F. M. Rees, deputy director, said recently. "I hate even to go to 9000 if it can be avoided. We don't want to become a big, big outfit. Our charm has always been that we are a small, well integrated organization that can do things very, very fast."

• **Nine divisions**—In the last several months, Marshall has added to its organization two new project offices —one for production operations at Michoud, the other for lunar program planning. The center's technical operations continue to be divided among nine divisions.

Eight of the technical divisions are based at Marshall. The ninth—the Launch Operations Directorate (LOD) —is based at Cape Canaveral.

—The LOD is responsible for all operations in connection with the launching of all NASA boosters and space vehicles on both the Atlantic and Pacific Missile Ranges. For this reason, there has been some consideration of a proposal to establish the LOD as a separate NASA center.

The eight technical divisions based at Marshall and some of their principal facilities include:

—The Aeroballistic Division, one of the smaller groups, conducts research in such areas as aerodynamic heating and external fluid properties. It also conducts flight evaluation of Marshall boosters. Its payroll totals 258 people.

The division's facilities include a 14-by-14-ft. trisonic wind tunnel, a 7-by-7-in. wind tunnel, a "hot shot" hypervelocity tunnel, and an atmospheric sounding station that takes soundings daily up to 100,000 feet. It currently has under construction a hypersonic shock tube tunnel, a hypervelocity gun and a *Saturn* jet deflector facility.

AERIAL VIEW of Marshall Center shows Saturn C-1 static test in progress. Facilities include 205-ft. superbooster dynamic test stand. Bigger stands are being built.

—The Test Division conducts tests of boosters and rocket systems and components. It also conducts R&D in testing methods. The division payroll totals 618.

The division's facilities include the *Saturn* static test tower which can accommodate a rocket system with a total thrust up to 2 million pounds and is being modified into a double superbooster stand. A second test stand that can accommodate boosters with up to 4- to 6-million pounds of thrust is under construction. Its cost: $10.8 million.

—The Fabrication and Assembly Engineering Division, widely known as the Fab Lab, is responsible for production of experimental superboosters and space vehicles and developing new technology and production methods. The division now operates in 22 buildings with a total floor space of 403,000 sq. ft. The division's payroll totals 841.

—The Quality Division is responsible for maintaining quality control on all vehicles. It also is responsible for maintaining a quality assurance program for launching systems and materials.

The division's main facility is an 111,000-sq.-ft. Checkout Building. Among other equipment, the division has an 18-ft.-diameter centrifuge capable of producing 30 g's. Total employees in the division: 399.

—The Research Projects Division is an idea factory under the direction of Dr. Ernst Stuhlinger. It is responsible for initiating and conducting original and supporting scientific research. The staff totals 65 people.

—The Propulsion and Vehicle Engineering Division conducts R&D in a wide variety of areas including structures, mechanics, propulsion, chemicals and materials. It has two main buildings and nine smaller buildings housing laboratories and shops. A new five-story addition is under construction.

The division's nearly $5 million worth of equipment includes a walk-in vacuum environmental chamber, a structural vibration tower, a 40-foot *Saturn* test tower and an aerodynamic heating simulation system. The division employs 730 people.

—The Computation Division operates one of the largest concentrations of computation equipment in the Free World. The Division has two main buildings. Its equipment includes two IBM 7090 computers, analog-to-digital conversion equipment, telemetry playback equipment, a frequency spectrometer, wave analyzer systems and a digital timing system. Total staff: 132.

—The Guidance and Control Division develops and performs pilot manufacture of guidance and control equipment. The main office and laboratory contains 192,000 sq. ft. Seven other buildings house various test and laboratory facilities. The division's special facilities include flight simulation equipment used for dynamic control studies. Total staff: 841.

• **In-house quality control** — The future of Marshall can be seen in its past.

As one top center official put it: "The government must be able to judge what industry is offering to it. There is a need for quality control. But to do this we always have had to have a good strong in-house project. Otherwise you quickly become out-of-date."

However, Marshall officials insist that this does not mean they seek to develop an arsenal system within NASA. As proof, they note pointedly that some 85% of *Saturn* hardware has been procured from private industry.

This is the pattern that is expected to continue to prevail. ■

Apollo Awards to Flow from Houston

Disbursement by new Manned Spacecraft Center may total $10-15 billion through decade; 90-95% going in industry contracts

ROBERT R. GILRUTH
From Mercury to the moon—and beyond

NASA'S NEWEST facility—the Manned Spacecraft Center now a-building at Houston, Tex., to handle *Apollo*—is destined to become one of its largest contract outlets.

Cost estimates for developing *Apollo* through 1970 vary from $10 billion to $15 billion—virtually all to be disbursed by MSC.

Renamed and expanded, MSC was formerly the Space Task Group which managed the *Mercury* program. Under its new charter, it will have not only the technical management and contract administration responsibility of *Apollo* and *Mercury*, but all of NASA's future manned spaceflight programs.

Of the billions to be spent by the center in the assault on the moon, NASA officials estimate some 90-95% will go in contracts to industry.

"We don't build anything ourselves around here," one official said, "even in our R&D programs we only build models and then contract with industry for the actual hardware."

The lion's share of the contracted funds will go to the three or four major contractors for the *Apollo* spacecraft development. Present plans call for one prime contractor to be responsible for the command and service modules and systems engineering for the whole spacecraft. Other contractors will be selected for the propulsion module, guidance and control, and the orbiting space platform which is still part of the *Apollo* program plan.

In the current fiscal year, MSC (STG) is spending $294.5 million. Some $54.2 million was allocated to Project *Mercury*, $156.1 million for *Apollo*, $24.1 million for salaries and expenses and $60 million for construction of the new Manned Spacecraft Center.

• **More funds, faces**—A top official says the budget will more than double in FY '63. MSC personnel complement will jump from its current 1000 to 1640. Eventually, the Houston facility will employ 3000 persons.

The new center will be headed by Robert R. Gilruth—the former director of STG. His top assistants will be Walter Williams and Wesley Hjornevik.

While the center's organization has not been finalized, current plans call for four main operating divisions.

These will break down into the following general areas: administration, research and development, preflight operations (including Astronaut training) and Project Office organization. The latter will have at least two divisions: one for *Mercury* and the other for *Apollo*.

Gilruth has not yet made a decision as to who will head the various operating positions, but the chiefs will undoubtedly come from top STG personnel. These could include: Paul C. Percer, Special Assistant to the Director, Maxime Faget, Flight Systems Division, Dr. Stanley White, Life Systems Division, Charles Mathews, Operating Division, G. Merritt Preston, Preflight Operations, and Bob O. Pilend—currently heading the *Apollo* contract evaluation.

• **Researching**—In addition to its contracting work in *Mercury* and *Apollo*, the Manned Spacecraft Center will be doing R&D work in the following fields including:

—Orbital Rendezvous—Many millions of dollars will be spent to determine the practicality of mating large vehicles in orbit for long journeys to the moon and planets. Much work will be done on this in Fiscal 1963.

—Follow-on manned space flight proposals including trips to Mars and 10- or 12-man expeditions to the moon. These will also involve R&D for spacecraft development.

—Life support systems for spacecraft.

—New techniques for spaceflight, including guidance and control.

—Astronaut training and R&D for their equipment and environment.

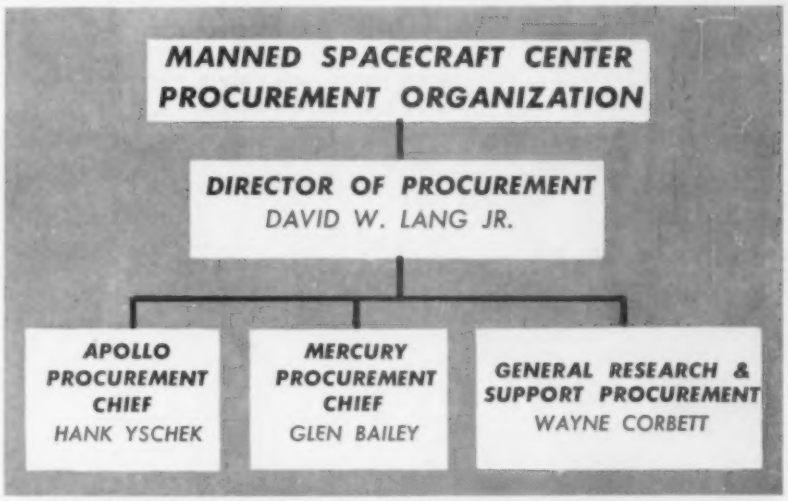
—Work on re-entry and landing following the manned lunar landing.

According to the current time schedule, some 400 persons actively engaged in the *Apollo* program will begin moving to Houston in late December. By early March, all of STG's manned lunar operations will be transferred to the new center. Project *Mercury* personnel will not begin to move until late next summer. All of STG is expected to be transferred to the new site by the end of 1962.

• **The Plant**—Major facilities at the center include:

—Flight Project Building—To house the executive offices, project engineering offices, flight systems offices, and central management services, an eight-story, $12,000,000 facility is planned. The building—providing approximately 340,000 sq. ft. of space—will serve as the management, engineering and service center for the Manned Space Flight Laboratory.

—Equipment Evaluation Lab—The Equipment Evaluation Laboratory and Support Facility provides the central services complex, including the shop and assembly areas for the preparation and repair of *Apollo* models and other equipment. The proposed buildings will be of standard milltype construction, with offices convenient to the shop and laboratory areas.



MANNED SPACECRAFT CENTER'S internal procurement organization. In January, 1961, the office had a staff of 15. It has now grown to 65 and will hit 100 by the end of the year.

—Flight Operations Facility—Consisting of a three-floor, 50,000-sq.-ft. office section abutting the laboratory and training facility area of approximately 70,000 sq. ft., the $3.6-million Flight Operations Facility provides an integrated center for the required mission simulation, as well as training equipment for the flight operations and training groups.

—Environmental Testing Laboratory—Facilities for testing the full-size *Apollo* spacecraft under critical in-flight environmental stresses will be provided in this testing complex. The main section of the building—a 100,000-sq.-ft. area—will provide for orderly spacecraft preparation, instrumentation, environmental testing and data handling. Adjoining the lab will be a two-story, 30,000-sq.-ft. office area and a submerged test cell of approximately 4000 sq. ft.

Other major facilities which will be needed in the future include:

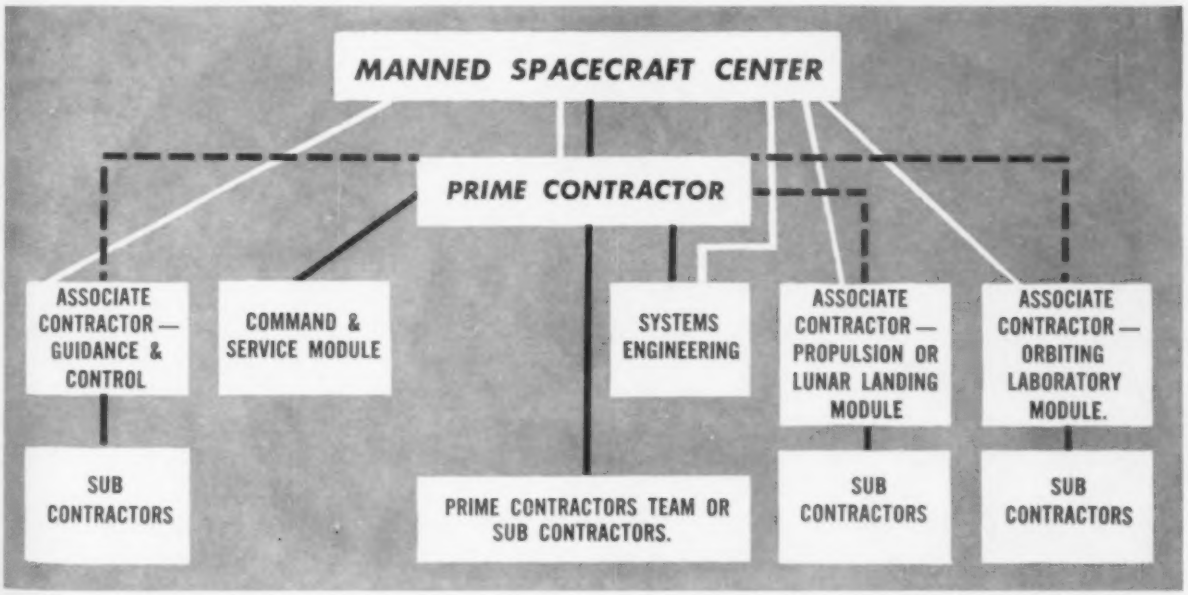
—An extensive antenna range facility.

—Extensive electronics laboratory.

—Land area and facilities for testing all systems engaged in the manned lunar landing program.

—Centrifuge simulation.

—Equipment to simulate a manned lunar landing with 1.6 g's. ⌗



APOLLO INDUSTRIAL TEAM—Prime contractor will be responsible for the command and service modules and the systems engineering for the whole spacecraft. Prime will also set specifications for other modules (White lines show flow of that information). Dash lines show flow of progress reports. Flow of funds is separate to prime and associate contractors.

EXPLORING THE HIDDEN SURFACE OF THE WATER PLANET

EG&G Underwater Camera, Light and Sonar System

Fig. I 17th Century Diving Bell.

More than one hundred million square miles of Earth's surface are completely unknown to man. These are the super-continents that lie more than a thousand feet under the ocean, where sunlight has never penetrated.

A total of about one square mile of this unknown world has been photographed in various oceans by EG&G automatic underwater cameras. Positioned by EG&G sonar equipment and using EG&G flash equipment for illumination, these cameras have made excellent photographs at 27,500 feet below sea level where the pressure is more than seven tons per square inch.

EG&G is also deeply involved in control instrumentation for the first nuclear rocket engines (Project Rover), the international program for detection of nuclear explosions (Project Vela) and instrumentation systems for non-military applications of nuclear explosions (Project Plowshare).

An informative brochure which describes the breadth and depth of EG&G's capabilities is available on request.

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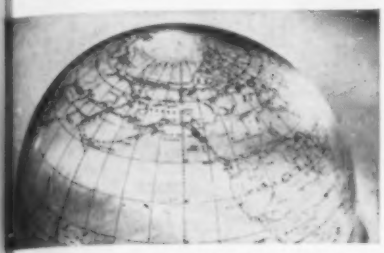

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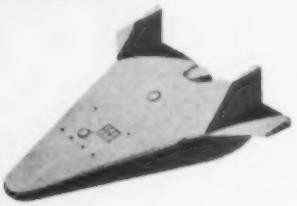
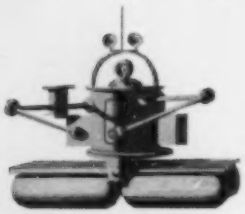
Nuclear Space Ship. An unconventional design by Douglas with living quarters around the ring at the bottom. On landing, it would ease down, ring first.

Nuclear Space Ship. A Douglas design for a space ship with crew quarters and control rooms in the nose, nuclear reactor in the rear.



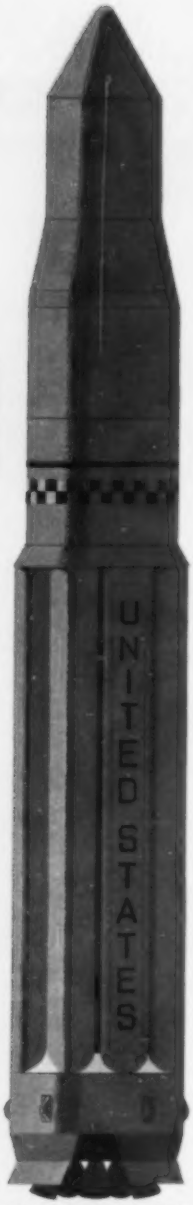
Supply and Escape Vehicle. A compact re-entry vehicle to supply orbiting space stations or to return crews to earth.



Lunar Service Vehicle. Travels like a "swamp buggy" on inflated rollers. Mechanical arms provided to handle outside chores.

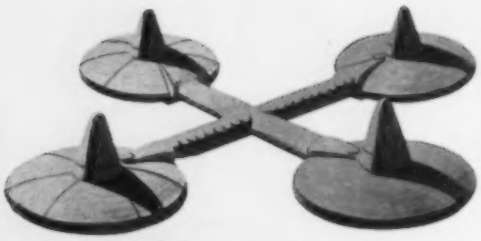
Nuclear Space Ship. A future, medium-thrust, nuclear-electric space ship for one-year interplanetary round trips (Martian and Venusian).

Douglas Thor. Designed as a military IRBM, this dependable missile is the workhorse of the Space Age.

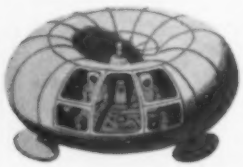


Saturn. First U.S. vehicle designed to put tons of payload into orbit . . . or onto the moon. Douglas-built second stage is as tall as a 4-story building.

Lunar Cargo Handlers. Would load lunar ore samples into containers to be towed back to earth by rockets.



Space Observatory. Sections of this Douglas-designed space station would be sent into space in rockets and be joined together in orbit.



Lunarmobile. Donut-shaped exploration vehicle to use rocket power in space and tractor treads on the moon's surface.

Eleven ways to outwit the law of gravity

When the Space Age dawned, Douglas was ready with specific proposals for space equipment either completed or in advanced stages of development. (Some appear above.)

These Douglas proposals were based on *realistic* estimates of the capabilities of men and materials. They are the valued dividends of the company's considerable experience, gained from the design and production of 30,000 missiles and rockets. These include the Douglas *Thor*, an IRBM which has been totally successful in 89.5% of its tactical and space firings over the past two years.

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Ryan Flex Wing enables helicopters to tow several times the cargo or fuel they can carry

Ryan has received several contracts from NASA and the military services to explore and develop the more promising Flex Wing applications. Pioneering an entirely new concept, such as Flex Wing, is typical of Ryan's Space Age capabilities.

Ryan Aerospace – Ryan Aeronautical Company, San Diego, California.

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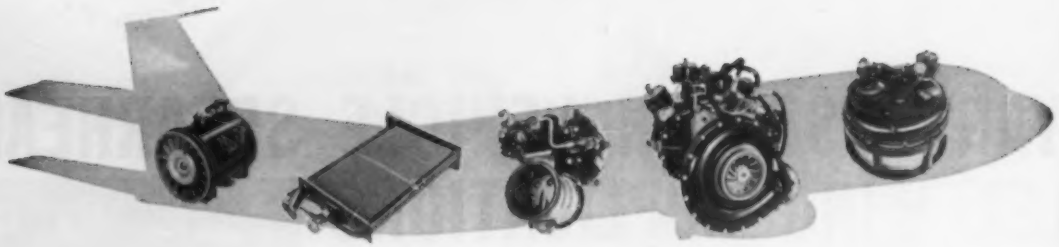
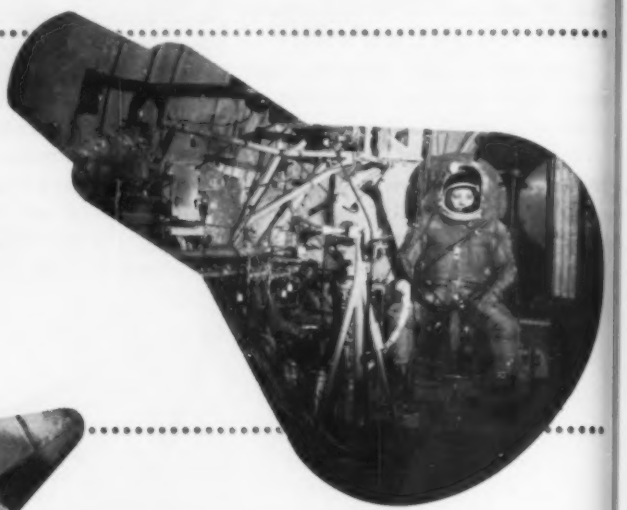
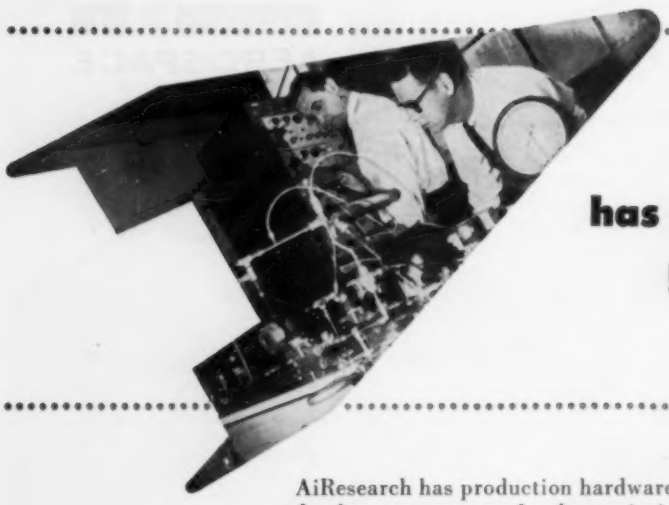


Only AiResearch has 2 million components in aircraft environmental systems*



Only AiResearch has life support systems for America's astronauts



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JPL Speeds Lunar Work for Apollo

As its expenditures double, Lab is expected to maintain or increase industry's lion's share of dollars

CALTECH'S Jet Propulsion Laboratory, with prime responsibility for NASA's instrumented exploration of the moon and planets, will nearly double these programs in FY '63 to meet the stepped-up demands of the manned space program.

This is the breakdown:

• **Lunar**—About $55 million more, including additional *Ranger* vehicles to support *Apollo*, and soft-landing *Surveyor* vehicles.

• **Planetary**—Program to be more than doubled by an additional $38 million.

Most of the step-up will occur in the lunar program, because of *Apollo* acceleration. Lunar program funding will be boosted to $109.5 million from its current FY 1962 figure of $64.3 million.

About $40 million of the additional money will buy four more *Ranger* vehicles designed to support *Apollo* directly by shooting closeup television pictures of the lunar surface before impacting on the moon.

More soft-landing *Surveyor* vehicles also are expected to be added, but how many remains to be determined, according to Clifford I. Cummings, JPL lunar program director.

JPL's planetary program, although not affected by *Apollo*, will come in for the biggest proportionate increase in Fiscal 1963, going to some $68 million, or more than double the current budgeted $30.5 million, Carl Jorgensen, manager of financial planning, told M/R.

• **Maintaining "mix"**—JPL's need to develop and maintain its ability to manage contractors affects its contracting procedures and how much money goes off-lab. R. J. Parks, planetary program director, said JPL must maintain "an appropriate mix" of in-house and contracted work.

"A sufficient fraction of the planetary systems programs will be kept in-house in order to keep up our capability," he said. "At present, this means JPL will keep the entire systems responsibility for *Mariner*. In the future, more and more of these projects will be contracted to industry. This may come in the *Voyager* series."

DR. WILLIAM H. PICKERING
No intention to compete in production.

Dr. F. E. Goddard, head of advanced planning, said details as to how JPL will spend much of its additional funds are yet to be determined because the unmanned program is under re-examination "to see that it will support *Apollo* to the fullest possible extent."

"Certainly, industry will have to provide a lot more of the known central needs of the program," he said. "This means more vehicles, tracking capability, and technical development in all fields. In order to accelerate the program, we will have to fire more vehicles in development and operational test runs."

• **Trend toward contracts**—A highly reliable industry cue is provided by JPL's outside spending in the past two years: In Fiscal 1961, the lab spent $50 million of its $79-million budget outside, and in the current year expects to commit $116 million of its $156-million budget to business and industry.

JPL has 262 contracts, with a current total face value of $52 million. These range from study programs to contracts for development of flight hardware and ground support equipment, with the main portion involving electronic design and fabrication. They also include contracts for JPL's continually-growing facilities.

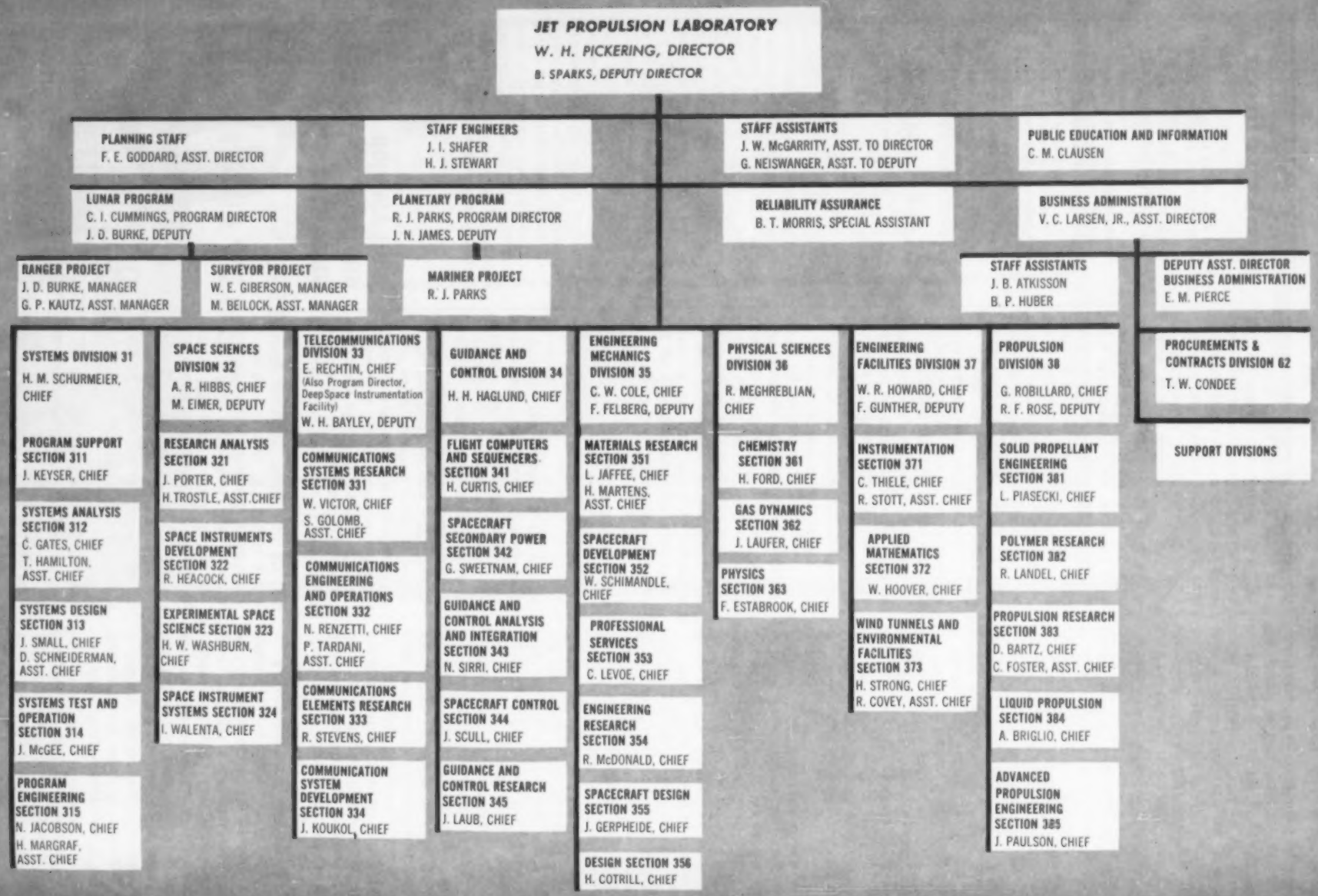
In addition, the lab spends about $500,000 a week through its purchasing section for everything from paper clips to basic off-the-self spacecraft items such as harness assemblies. The lab's latest six-month report shows that about 70% of the purchasing section awards, totaling 40% of money spent, go to small business.

As a non-profit organization operated by CalTech under NASA contract, JPL's policy is to spend the major portion of its funds outside the laboratory. "We have no intention of becoming engaged in production-type activities in competition with industry," says JPL Director Dr. William H. Pickering.

Pickering's deputy for business administration, Val Larsen, whose support organization employs more than a third of JPL's staff, said the laboratory's problem "is to get this big job done, and we don't have the facilities or manpower to do it in-house." JPL has a staff of 2847, of which 863 are scientists and engineers.

"What must be done here is fundamental research, origination of concepts, and some advanced development work on hardware that might be used to accomplish a mission five years from now," Larsen said. "There are certain components or subassemblies which are beyond the present state of the art and which must be proven feasible before they can be handed over to industry for further development."

• **Other factors**—In addition to in-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creased space effort, there are two other factors which should mean a rise in the amount of business JPL lets out:

—The continual demand for new capabilities.

—Plans to turn over to industry some of the work JPL now does in-house as a matter of its own staff training.

When full responsibility is kept in-house, JPL goes to its technical divisions for the subsystems. The divisions, in turn, almost always go to industry. In the second case, JPL selects a contractor to design, build and fire the vehicle.

Parks pointed out that even when JPL retains full responsibility, a high percentage of the money goes off-lab—about 75% in the case of *Mariner*, which currently accounts for about 95% of the entire planetary program budget.

In the lunar program, JPL has retained *Ranger* in-house, while contracting for complete spacecraft systems responsibility for *Surveyor*. JPL developed the prototype vehicle for *Ranger* and then asked about 1500 subcontractors and suppliers to provide the hardware.

Prospector, on which decisions still are to come on how it can best support *Apollo*, will be an out-of-the-house program.

• **Contractor contracts**—In outlining procurement policies, Larsen emphasized that the lab is a contractor to the government in the same way an industrial firm may be a prime contractor. Thus, in working under JPL contract, a firm is, in effect, dealing with "another commercial organization" under subcontract.

If the laboratory knows exactly what it wants as to specifications, the industry assistance and evaluation group provides a list of qualified firms who are asked to submit proposals. The result usually is a fixed-price contract.

Cummings gave M/R this rundown on procurement procedure involving a major project such as *Surveyor:*

"A lot of people in industry are doing informal studies based on very broad guidelines. They develop conceptual advanced studies and then ask for a preliminary run-through on our thinking in hope of getting us to react. We agree to these presentations on the basis that these people definitely have something to contribute. We gain some ideas, and, we hope, they get a better picture of our thinking.

"Meanwhile, as the status of launch vehicles and overall scheduling and funding begins to ripen in NASA planning, we go to NASA headquarters with a preliminary project development plan. This gives NASA a broad outline of what we expect to set forth on mission objectives, scheduling, and gross funding. We also indicate project management and procurement procedure.

"After NASA approves it, we are free to invite 30 or 40 contractors to a bidders' conference. In the lunar program, we want those who have been here before and have something worthwhile to contribute, those with obvious systems talent. In the planetary program, you get a different twist—they may be looking for subsystems contractors.

• **Spreading the word**—"At the conference, we try to give good information so those attending can pass it on to the subsystems people. In the *Surveyor* program, conference tape recordings were sent to all who attended.

"Our object at this stage is to choose some contractors who will perform the competitive (partially or fully funded) studies. For this we want organizations that can go beyond the study stage and perform the full responsibility.

"But we do not want a technical proposal at this time. We want a proposal on how a contractor would carry out the study, how he would manage the project, and how he would organize to handle the actual hardware program. The selection process is very sensitive to what he plans to do. We also want the names of the (company) people who actually will be doing the work.

"After these proposals are in, we select the few competitive study contractors who really can do what they say they can do. We select, say three, to do a formal (paid) study. We provide them with the requirements and constraints as the basis for their competitive design studies.

"When they have finished, they turn in the studies along with their proposals for implementing the program and their proposal on program approach—how many test vehicles, how much money, phasing, manpower.

"Next, a source evaluation board is formed of senior JPL people and NASA representatives. The board's findings are given to the NASA Administrator. He makes the selection, and then we can enter contract negotiations."

Cummings said JPL is "not interested" in unsolicited proposals by the time the bidders' conference is called. However, JPL welcomes all informal proposals.

Since Dec. 3, 1958, when the government-owned laboratory was transferred to NASA, JPL has built up a capability to conduct any phase of systems work and research on unmanned space missions.

Following transfer to NASA, JPL underwent a complete reorganization which resulted in creation of eight tech-

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nical divisions: systems, space sciences, telecommunications, guidance and control, engineering mechanics, physical sciences, engineering facilities and propulsion.

Support activities were grouped into six service and support divisions: personnel and technical services, procurement and contracts, financial management, plant engineering services, material services, and fabrication services.

• **Shopping**—In keeping with the policy of "making the fullest possible use of industry," the technical divisions often go off-lab for 60% or more of their needs.

Dr. Albert R. Hibbs, chief of the space sciences division, mainly concerned with scientific instrumentation with which to explore space, said his organization prefers to have industry develop its flight hardware.

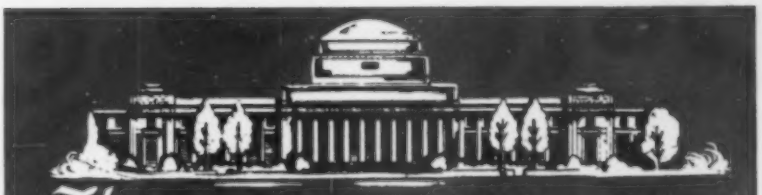
"But we customarily do not turn to industry for scientific research," he added. "We find that generally the stronger scientific inputs and research concepts come from universities, where the people have time to devote thought to it."

Fabrication services division is another example of how JPL must go outside to fill its needs. The division, while operating a fully-equipped machine shop, can provide only 20% of what must be fabricated for research and development purposes.

• **Plant growth** — JPL's 140-acre Pasadena installation, which currently consists of 180 buildings totaling 598,000 sq. ft., three wind tunnels, and 180 leased trailers, is authorized in its FY '61 and '62 construction program to spend $10.6 million for another 291,000 sq. ft. of office, laboratory, and shop space. In FY '63, JPL plans to add another 180,000 sq. ft. of similar facilities at a cost of $7.3 million. Present facilities are worth $35 million.

Existing facilities, in addition to the Pasadena installation, include the Deep Space Instrumentation Facility spread over 50 sq. mi. at Goldstone Dry Lake, Calif., and consisting of two 85-ft. antennas and 16 support buildings; a 590-acre propulsion research and development facility at Edwards AFB, Calif.; and engineering and testing installations at Cape Canaveral, Fla. The DSIF also has stations at Woomera, Australia, and Krugersdorp, South Africa, with giant receiving antennas.

The Edwards AFB installation, which has four test stands and employs 50 persons, is in the process of adding $1.3 million in new structures for solid-propellant research, including a new test area and a solid-propellant processing facility. ■



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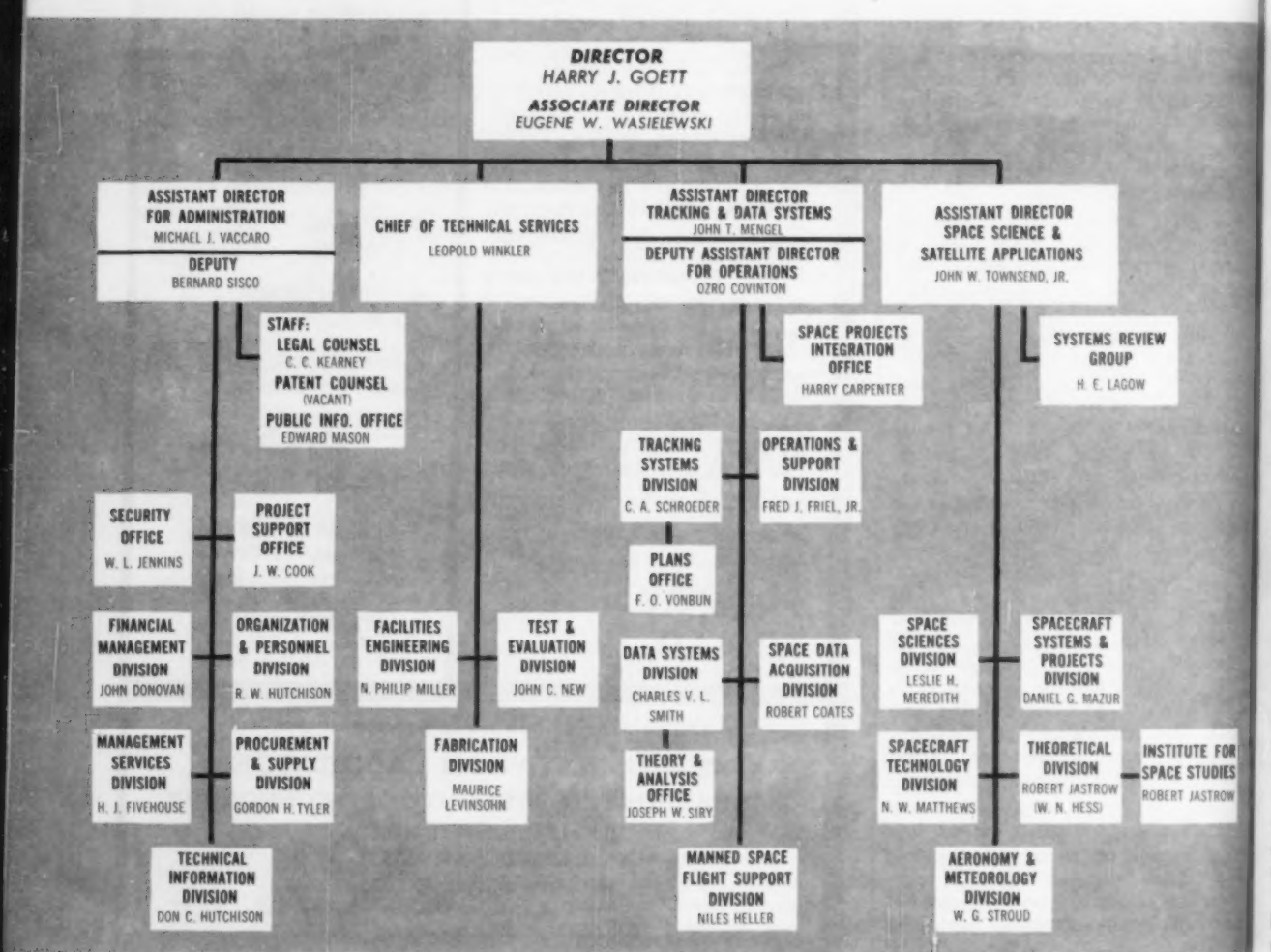

Mainly for Unmanned Craft

GODDARD Space Flight Center, newest of NASA's nationwide complex of installations, is expected to receive a 25% increase in its FY '63 budget to push the unmanned satellite program.

The 25% boost would increase spending at Goddard to about $250 million a year.

Moreover, Goddard will receive an additional boost in funds from the Weather Bureau specifically for the development of weather satellites.

The bulk of Goddard's budget will continue to be spent on the unmanned satellite program. However, the center is also expected to play a major role in tracking in the *Apollo* program.

Judging from precedent, industry can expect to get upward of 80% of the Goddard budget for contracted R&D, which includes money for supplies and materials for the Center's in-house research.

• **$162 million for R&D** — Since Goddard's end product is scientific data, the Center's organization chart reflects a corresponding emphasis. Thus, of the four assistant directors reporting to the Center's director, one is in charge of "Space Science and Satellite Applications," and the other, "Tracking and Data Systems." The two remaining assistant directors take care of technical services and administration.

The Space Science and Satellite Applications group—the largest, with between 600 and 700 people, has two application satellite programs: meteorological and communications. R&D for these command the most money—$62 million out of Goddard's $162-million-budget for FY '62 R&D. (Goddard's total budget for FY '62 is $206 million.)

Runner-up is the scientific satellite program, budgeted at $44 million for R&D.

• **Application satellites**—The meteorological satellite program consists of *Tiros*, *Nimbus* and the follow-on operational weather satellite, *Aeros*.

Three *Tiros* satellites have already been successfully launched and five more launchings are planned for the next year and a half. Intended to scout the earth's cloud cover, the advanced *Tiros* satellites will see successive growths in their infrared instrumentation, with continuous orientation to the earth for photo purposes.

First launching of the second-generation weather satellite *Nimbus* is expected toward the end of next year. From that time on, one *Nimbus* is to be operating in orbit almost continuously.

R&D for the 24-hour meteorological satellite *Aeros* is not expected to start for a few years. Studies indicate, however, that the operational system will use three or four satellites displaced around an orbit.

Only now being figured into NASA's planning is one factor that may spur the meteorological program on: early in October, President Kennedy signed a bill giving the Weather Bureau $48 million to carry out a weather surveillance program. Of this money, Goddard will receive and spend about $45 million on systems management.

"Our job is to provide and operate the weather satellites and ground stations," a top NASA official told MISSILES AND ROCKETS. "We're starting now."

This $45 million—part of the supplemental FY '62 budget—will enlarge Goddard's staff beyond the projected 2300-man payroll expected by the end of this calendar year.

• **Communications satellites** — The communications satellite program, comprising passive and active types, is getting a big push because of commercial as well as government interest.

Next year, the 135-ft.-balloon *Echo II*, a passive communicator, is to be launched. Subsequently, under the *Rebound* project, an attempt will be made to launch three or more *Echo*-types from a single *Atlas-Agena* vehicle and to disperse them in orbit.

Among the active communications satellites Goddard is involved in are: *Relay*, an active transponder being developed by RCA for launch in late 1962 or early 1963; *Syncom*, a 24-hr. repeater with spin and altitude stabilization, being developed by Hughes for late 1962 or early 1963 launch; and *Telestar*, an AT&T experimental industry communications satellite, the first of four scheduled for 1962 launching.

Goddard scientists say that the biggest problem is to develop a communications satellite that will continue to operate for long periods. Solving this problem involves getting an altitude control with adequate reliability, and a power supply that is rugged, light, and long-lived—this last, the universal quest of equipment developers.

• **Scientific satellites** — The scientific satellite program includes orbiting solar observatories *(OSO)*, orbiting astronomical observatories *(OAO)*, orbiting geophysical observatories *(OGO)*, an atmospheric structure satellite *(S-6)*, a series of satellites for international programs, principally geodetics, and several others.

Preparations are now being made for launching an *OSO*—a stabilized satellite whose instruments point at the sun. About six *OSO*'s are expected to be sent up in the next two or three years; after this, improved *OSO*'s will be sent up in a continuing program.

The plan is to start launching *OAO*'s in late 1963 or early 1964, and continuously after that. The hope is to have one operating in a satisfactory orbit at all times, which may involve one or two launches a year.

OGO will be the workhorse for the geophysicist, taking from 30 to 50 different experiments on each satellite. The 1000-lb. satellites—scheduled for first launch in 1963—will be sent on polar orbit *(POGO)* or on a highly elliptical orbit *(EGO)* similar to the *Explorer XII*.

The *S-6* will be sent up next year to measure density, pressure, temperature and composition of the upper atmosphere.

The first of the international scientific satellites *(S-51)* will be launched for the United Kingdom in 1962. A second U.K. satellite *(S-52)* is in early phase development. Goddard is also providing management for launching a

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Canadian topside sounder *(S-27)* which is to go into a polar orbit in 1962.

• **Tracking and data handling**—Another $44 million of the Center's FY '62 R&D budget will go to industry for tracking and data work, which includes updating equipment, and operating and maintaining *Mercury* and Minitrack networks.

Funding for Goddard Space Flight Center

(millions of dollars)

	FY '61	FY '62	FY '63 (est.)
Contracted R&D	213*	162	200
Salaries & Expenses	25	28	37
Construction & Expenses	14	16	15
Total	252	206	252

** Includes $87 million to support the Space Task Group, then a part of Goddard.*

For manned spacecraft such as the coming *Apollo,* Goddard directs a global ring of stations which provide tracking, telemetry and communications activities. Dual IBM 7090 computers, with "real-time" channels, make constant flight contingency recommendations and predict flight paths, impact points of the capsules and velocity vectors on a near zero-lag continuing basis during the mission.

The tracking problem for unmanned as well as prospective manned vehicles is expected to grow increasingly difficult, particularly with scientists wanting increasingly radical orbits. Moreover, the data-handling and reducing problem becomes monumental.

"We're good customers of the computer companies," a NASA engineer said. "We're always on the lookout for ways to handle our data faster and cheaper. Man, what we wouldn't give for this!"

For each hour *Explorer XII* is in orbit, it costs the Center an hour of data reduction. In 32 days, the satellite's telemetry filled 3200 magnetic tapes. "We could never reduce all the data," the engineer added. He pointed out that the center has five IBM 7090 computers and also rents time outside, "and it's still an unrealistic job."

Even so, the Center is striving to cope with the problem. The data handling group was expanded recently and is trying to do as much data reduction as possible for the experimenters—short of final scientific reductions.

• **Sounding rockets**—The sounding-rocket program—the upper-atmospheric program that came from the Naval Research Laboratory—accounts for $7 million of the R&D budget. The vertical probes are used for exploring in and beyond the earth's atmosphere. They are also used to test out instruments destined for satellite work.

The 1961 schedule called for 83 Goddard-managed sounding rockets to be launched. Over 175 launchings are planned for 1962, and these include some shots made in cooperation with England, Australia and Japan.

Other R&D programs amounting to $2 million bring the total Center expenditure for contracted R&D for FY '62 to $162 million.

The total R&D program budgeting is based on "incremental" programing that is, programs are budgeted on a yearly basis. (Goddard's budget does not include the cost of launch vehicles which are paid for out of NASA headquarters money.)

• **Goddard's non-R&D money**—Approximately $28 million out of the Center's current budget is going for salaries and expenses, which includes equipment and computer rentals in addition to building rentals. Moreover, $16 million is earmarked to continue the Goddard construction program; this figure also includes $6 million for Minitrack network buildings and facilities.

The Center is located on 550 acres in a rural area near Greenbelt, Md., about 10 miles northeast of Washington. With four major buildings completed and occupied and four more under construction, the space agency complex will comprise 11 buildings before the end of 1963 at a total cost of more than $37 million.

Most of Goddard's personnel are at the Greenbelt site or occupying temporary space which will be vacated as soon as the appropriate Center buildings are finished. However, some members are operating world-wide tracking network stations under Goddard's far-flung operational communications wing.

In May, the Goddard Institute for Space Studies was established in New York City. Its mission is to build up the space program in its broadest scientific aspects. Headed by Dr. Robert Jastrow, the facility was put in New York so there could be an easy interchange of ideas between NASA and the universities. There are 25 people in the group now—fellows, professors and graduate students besides NASA personnel—and it is expected to go to about 40.

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• **Selling to Goddard** — All the money that Goddard spends with industry goes through the Procurement and Supply Division, headed by G. H. Tyler. Usually, major procurement—essentially R&D—commands 90% of the money, leaving about 10% for standard purchases such as off-the-shelf items.

Goddard buys all the equipment and facilities needed to support its mission.

Potential R&D contractors and prospective suppliers are strongly advised to make their initial contact with H. J. O'Toole, Chief Facilities Source Office, Goddard Space Flight Center, Greenbelt, Maryland. (The present physical location of this office is in Washington, D. C.)

Since O'Toole is fully informed about the needs of Goddard, he brings technical personnel into meetings with appropriate Center R&D contractors. Where needed, he performs a similar service for suppliers.

In addition, O'Toole circulates to interested Center personnel the company literature and brochures furnished to him. Moreover, he maintains the procurement source file which is the basic reference file used by the Procurement and Supply Division.

Companies wanting to do business with Goddard are urged first to write a letter to O'Toole, including with it: (1) Standard Form 129 (application form for being entered on bidders' list); (2) DD Form 558-1, which is supplement to Form 129; (3) biographies of scientific and engineering staff (for R&D contracts); and (4) supporting brochures and other pertinent literature. (The forms can be had from any government purchasing office, civilian or military.)

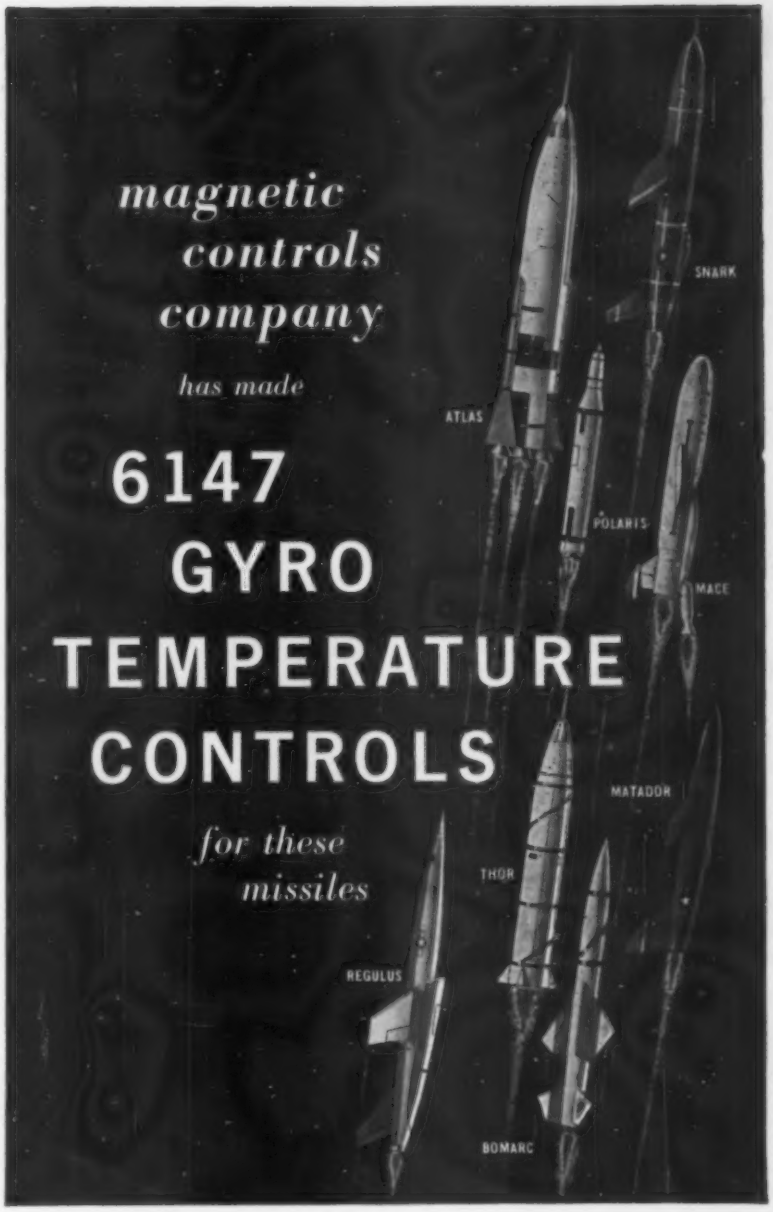
The division is adamant about not wanting "strollers" or subcontractors to visit.

The Division also suggests that suppliers of parts and equipment correspond rather than visit—unless a unique product or breakthrough is involved. If a visit is planned, then the Division recommends that a letter be sent to set up an appointment.

R&D proposals under one million dollars may be evaluated by a Board of technical and business personnel. The procurement decision is made by the contracting officer.

When the proposal involves expenditures of over one million dollars, the Board evaluates it according to preestablished criteria, and the decision is made by the Center's Director.

When over $5 million is involved, the Board again evaluates but the final decision is made by the NASA Administrator. (These procedures do not apply to building construction contracts.) ⌗



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WOO Awaiting West Coast Upsurge

Staff of Western Operations Office being doubled in anticipation of lunar program; business now tops $603 million

THE WESTERN Operations Office —nicknamed WOO—is NASA's contract manager and technical watchdog on the West Coast.

As WOO Deputy Director Donald R. Mulholland explains it: "We receive a steady stream of queries from NASA centers asking what is going on in industry. We go and ferret out the information."

However, the primary mission of WOO, which has no R&D facilities, is contract negotiation and the management of R&D contracts with West Coast companies.

In FY '62 alone, WOO Director Robert W. Kamm expects his group to disburse nearly $300 million in contracts. In the same period, WOO's internal budget is only $1.4 million. WOO's staff is currently being nearly doubled to 119.

• **The Big Seven**—The office currently lists on its books 201 contracts, worth $603,030,000. Of this number, WOO actually has contract management responsibility for only 62, acting in a supporting role on the others. The 62, however, add up to $535,409,000—of which all but $3.6 million is contained in seven major contracts.

The seven include: California Institute of Technology's Jet Propulsion Laboratory, $227,190,000; *Saturn S-IV* (Douglas Aircraft Co.), $81,890,000; *Saturn S-II* (North American Aviation), $975,000 (currently negotiating for a nominal size of $150 million); F-1 engine (North American Aviation), $109,358,000; H-1 engine (North American Aviation), $37,525,000; J-2 (North American Aviation) $46,450,000; *Delta* vehicle (Douglas) $28,353,000.

Earle J. Sample, WOO's contracting officer, gave this rundown on contracts:

ROBERT W. KAMM
Organized across-the-board for big push

"The 62 contracts have been assigned to this office for contract management. The remainder are contracts on which I am not contracting officer, but on which this office has been delegated a supporting role of some sort.

"This includes project monitoring, perhaps making payments, and giving expediting assistance. In some cases, a NASA center feels that the contracting officer ought to be at the center. A contract may be somewhat sensitive. Sometimes a contract may not be big enough to warrant the administration delay of transferring it out to us. It may be a one-shot study job."

• **Subcontract control**—In explaining his role, Sample said that in the event a contractor, such as the Jet Propulsion Laboratory, wants to place a subcontract, it must obtain his permission and provide assurance that the proposed subcontractor can perform technically and financially and that his price is fair. In the case of small subcontracts which do not require prior consent, Sample maintains surveillance by reviewing purchasing procedures.

In project monitoring, members of the technical staff act as on-the-spot representatives of NASA project offices that are involved.

Still another part of the technical mission is quality engineering.

"Our technical people, through surveys and inspections, evaluate the effectiveness of the contractors' quality and reliability programs, and make recommendations where improvement is needed to meet NASA's high reliability requirements," WOO director Kamm said.

• **Balanced team**—To meet its tasks, WOO has an "across the board organization" which includes contract administrators, engineers, scientists and attorneys. In addition to the technical division, there are divisions for contracts management, financial management, administrative services, security and public information, WOO also has a legal office employing three patent attorneys.

An added responsibility is providing administrative support for personnel which other NASA centers assign to projects in the Western area. About 50 NASA representatives currently are on such assignment, including those in a headquarters audit group, an *Agena* project group at Sunnyvale, Calif., and a *Centaur* project group at General Dynamics/Astronautics in San Diego, Calif. ■

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Technicians prepare prototype pulse rocket firing during one of continuing series of tests.

Firing of integrated design, pulse modulated control rocket at Vickers Research and Development Laboratories.

Pulse modulated control rocket fired

Bipropellant, integrated rocket design developed by Vickers for space vehicle control

Successful firing of a pulse modulated bipropellant control rocket at the Research and Development Laboratories of Vickers Incorporated marks a significant upward step in space vehicle control devices. The pulse rocket features a unique integrated design concept to insure reliability, fast response, high efficiency and low power input.

Higher Reliability with Less Weight—The single solenoid design insures perfect synchronization of fuel and oxidizer valves. It also accomplishes the objectives of reducing weight and increasing reliability. Shortened flow passages of manifold design for the hypergolic bipropellant (N_2O_4 and N_2H_4/UDMH) further reduce overall weight and provide added structural strength.

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Logical Extension of Know-how—Vickers unmatched experience in design and development of fluid power controls, components and systems with a particular emphasis on low weight, high response and high reliability provides a solid base for work in the relatively new field of space vehicle reaction controls. The intensive development program has evolved a basic design principle that can be readily applied to provide control rocket thrust levels to meet any forseeable requirements.

Get more details by writing for Bulletin A-6005. Vickers Incorporated, Division of Sperry Rand Corporation, Detroit 32, Michigan.

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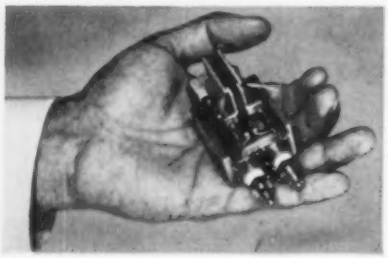
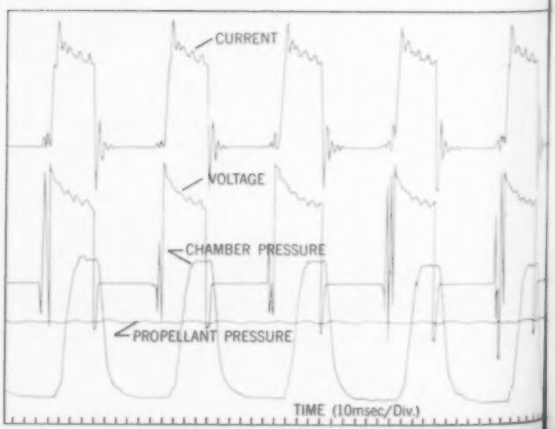


Prototype pulse rocket designed for thrust level of 1 lb. Basic design concept is applicable to any forseeable control rocket thrust level.



Recording of pulse rocket firing showing typical system response.

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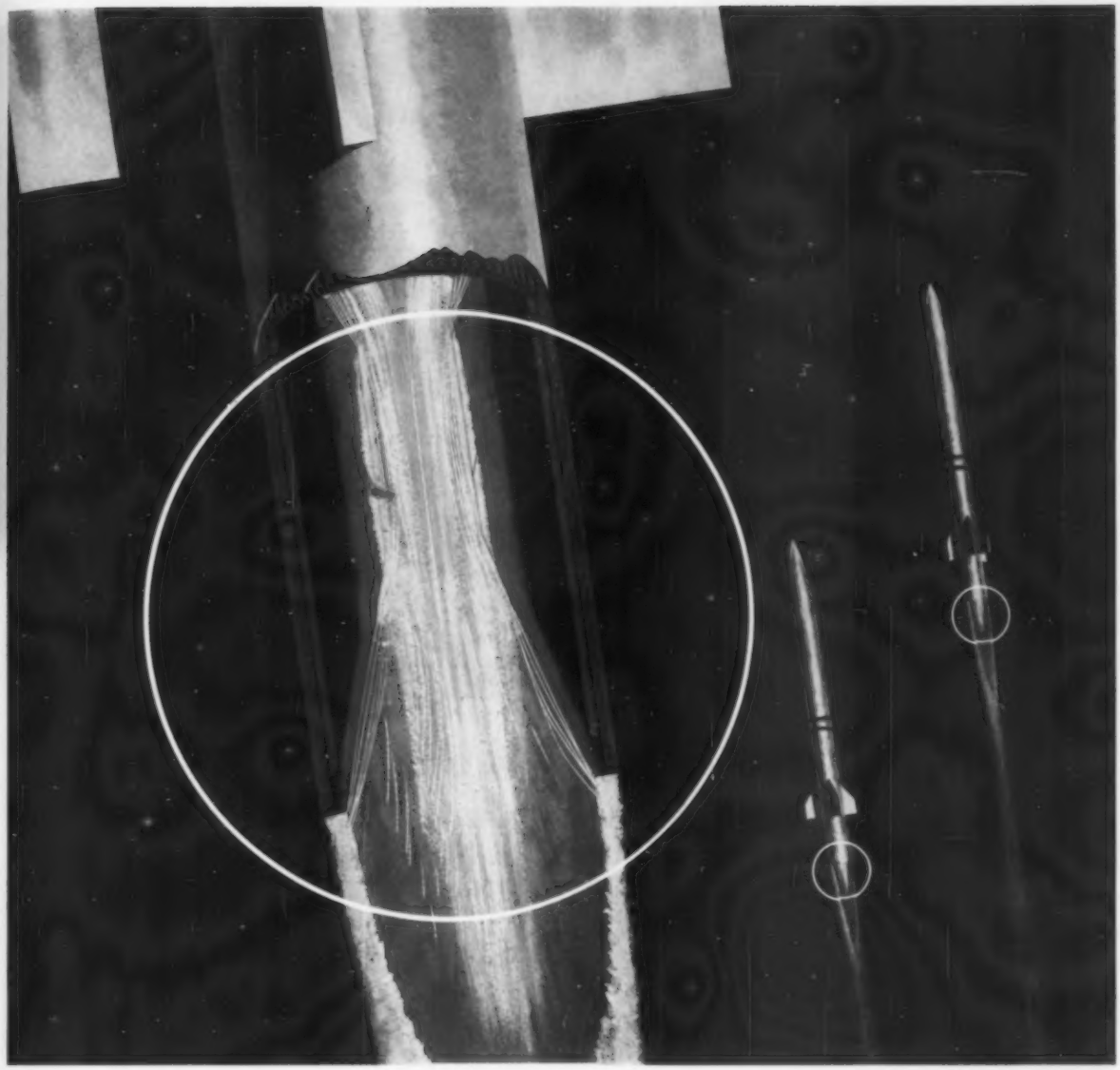

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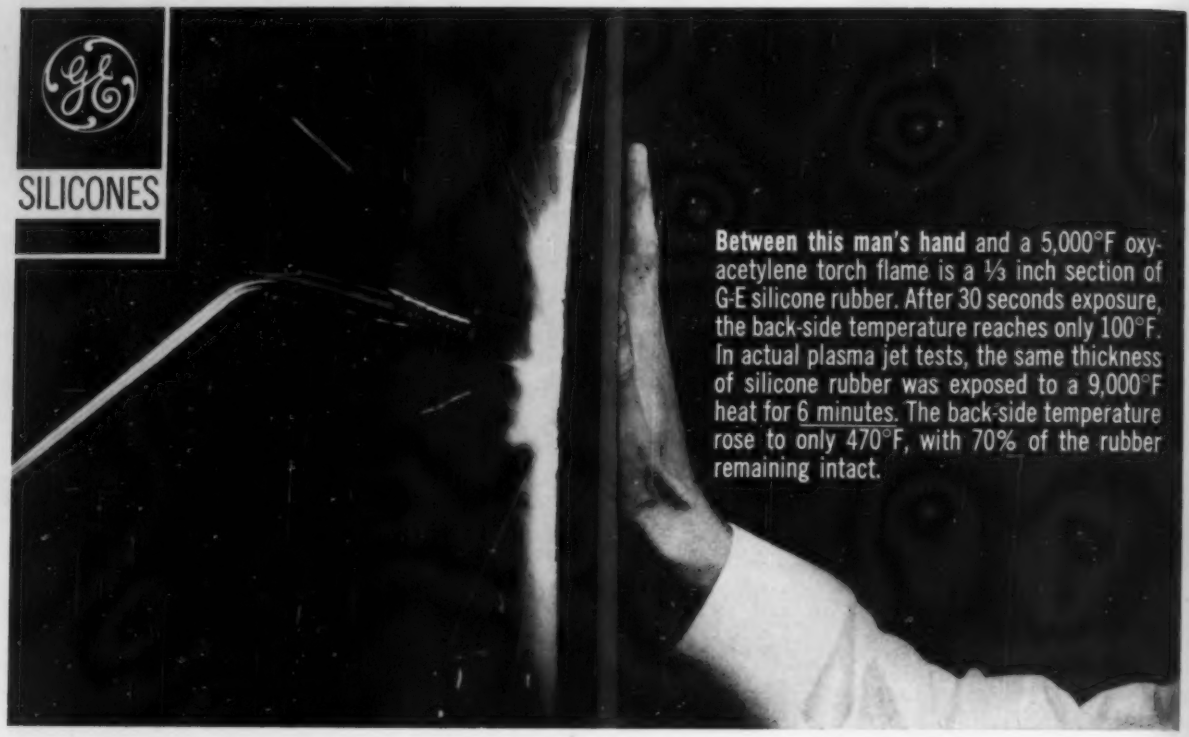

Between this man's hand and a 5,000°F oxy-acetylene torch flame is a ⅓ inch section of G-E silicone rubber. After 30 seconds exposure, the back-side temperature reaches only 100°F. In actual plasma jet tests, the same thickness of silicone rubber was exposed to a 9,000°F heat for 6 minutes. The back-side temperature rose to only 470°F, with 70% of the rubber remaining intact.

Thermal barrier against 5000°F flame

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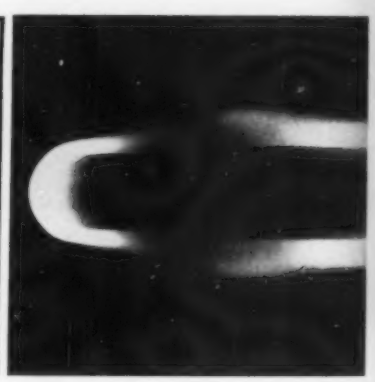
The surface of the tested rubber section forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

RESULTS OF PLASMA JET TESTS AT 9,000°F

Flight Simulation
Vel. = 17,000 ft./sec.
Alt. = 250,000 ft.

Exposure time at 9,000°F	Back-side temperature of ⅓ inch section of G-E silicone rubber
30 seconds	100°F
2 minutes	210°F
3 minutes	300°F
4 minutes	375°F
5 minutes	430°F
6 minutes	470°F

The above chart shows how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.



Continued high temperature testing goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section 01161 Waterford, New York.

GENERAL ELECTRIC

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Cape's Billion-dollar Launch Complex

Launch Operations Directorate due for 500% increase in funding next year, plans matching hikes in personnel and land area; Saturn pad-building starts next year

DR. KURT DEBUS
His staff and budget begin to quintuple.

THE VAST Cape Canaveral spaceport, from which multimillion-pound-thrust boosters will soar to the moon and beyond, will cost the United States well over $1 billion by 1970.

For FY 1963 alone, NASA's Launch Operations Directorate at the Atlantic Missile Range is seeking a total budget of $500 million. Some $246 million would be earmarked for the U.S. manned lunar landing program, $17.8 million would go to R&D activities, $9 million for salaries and expenses, and $8.5 million for plant support.

In FY '64 and FY '65, it is estimated, the Cape's budget will hit $200 million annually.

The sharp upsurge in spending compares to a FY '62 budget of a little over $100 million—$80 million for construction, $19 million for R&D, and $6.5 million for salaries and expenses.

With the increased budget will come a corresponding increase in employment. LOD's total force will jump from the current 510 people to 800 by mid-1962. In the 1965-66 period, it is expected to soar to 5000.

Both the funds and added personnel stem from the expanded U.S. space program, which is forcing a five-fold increase in the land area of NASA's Cape Canaveral installation. It will jump from its present area of 20,000 acres to 100,000 acres—25 miles long and 10 miles wide at its broadest point.

Into the expanded area will go launch pads and facilities for giant *Saturn* and *Nova* boosters, an industrial area, and support and management buildings.

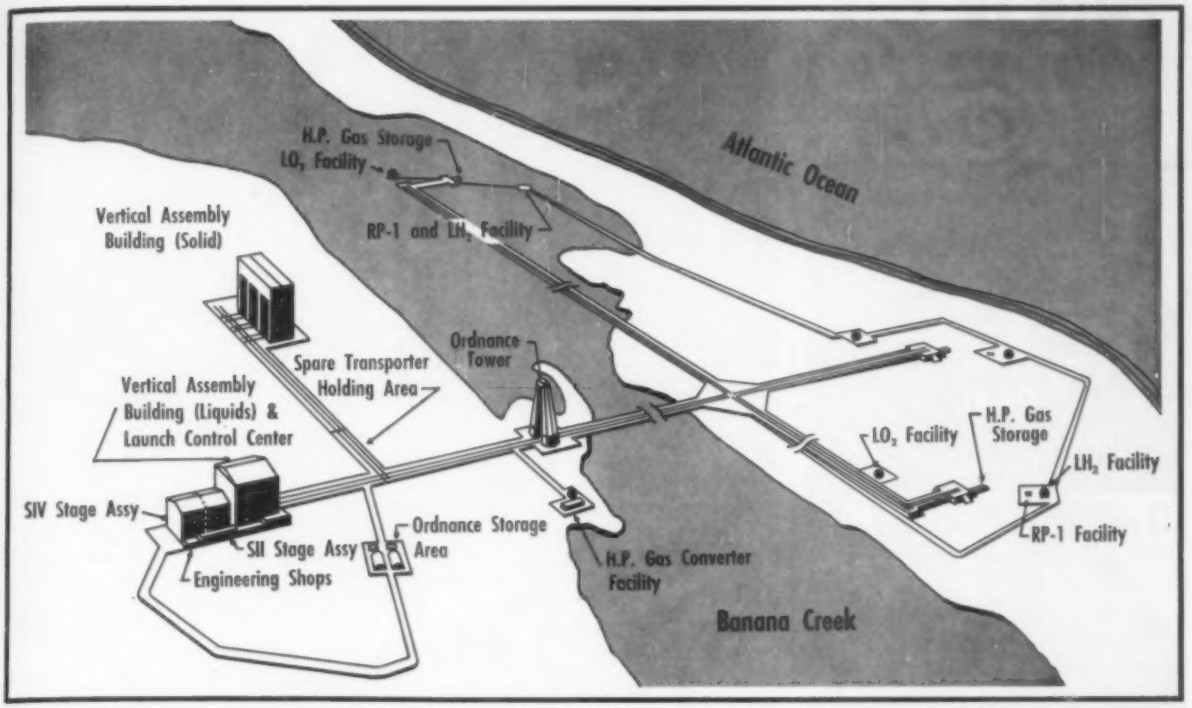
Land acquisition will be handled by the Jacksonville, Fla., district of the Army Corps of Engineers. The first purchase, totaling $18 million, will be made shortly. Further funds to accomplish the total land purchase—estimated to cost $60 million—will be requested from Congress early next year.

To meet its additional procurement needs, LOD is setting up its own procurement office. This had been handled earlier by the Marshall Space Flight Center to which LOD reports.

• **Planning for C-4**—Top procurement officer in the new operation will be Gerard Michaud. His office will be awarding contracts for ground support equipment, research and development area, and facility support purchases. At present, the office has a small staff, but it may eventually employ approximately 50 persons to handle the procurement and contract negotiation for the giant *Saturn* pads on which construction will begin next year.

Plans and specifications for the giant pads were prepared by LOD under the direction of Maj. Rocco Petrone—a U.S. Army officer currently on duty with NASA.

So far, plans for the first *Saturn* pad are based on the premise that it would be used to launch the *Saturn C-4* boosters, which would have four F-1 engines developing a total thrust in its



LOD DRAWING of planned Saturn C-4 launch complex with two to three pads. This version utilizes the rail transporter, but would not differ too much if the barge-canal transporter concept were selected (see sketch on p. 118).

first stage of 6 million lbs.

LOD's specifications call for a *Saturn C-4* complex with three launch pads, which would be capable of 25 launches per year. Thus, the complex could easily handle the launch requirements of the "orbital rendezvous" concept of space flight. All of the proposed configurations for the second-generation *Saturn* vehicle are slated to play a role in "rendezvous" if it proves feasible.

Total cost of the complex is estimated by NASA officials at $300 million to $500 million.

The most imposing structure will be the 450-ft.-tall Vertical Assembly Building. According to current plans, it will have six bays in which the giant *Saturn* vehicles will be assembled and checked out. LOD has also made tentative provisions for a large building in which large solid boosters can be prepared if they are tabbed for a role in the lunar program.

After checkout in the VAB, the launch vehicles will be moved to the launch pad, where an additional week's checking will take place.

• **Canals and Texas Towers**—Two methods are being considered by LOD. One would utilize a giant transporter on a rail line. The second method calls for the construction of a canal and a barge transporter.

LOD estimates that the barge-canal method would cost $250,000 per mile and the rail version some $4 million per mile. But the rail concept has certain advantages—including speed and more stability for the vehicle.

The rail bed will have to be capable of supporting 6 million pounds. Its transporter will be 150 ft. long and 90 ft. wide to handle the *C-4*'s planned 396-in. diameter. The transporter will have a 350-ft.-high umbilical tower for *C-4* launch and 20-ft.-long hold-down arms.

In the barge-canal concept, a Texas Tower would be utilized to jack up the barge 40 or 50 ft. It is also possible that a lock in the canal could be used to boost the barge up to the height of the pad. The barge-transporter would be 150 ft. long and 110 ft. wide.

In both plans the transporter and the umbilical tower are the core of the system because the vehicle will be fired from them. Each of them will contain all the electronic GSE needed for a launch operation.

As soon as a final decision is made on specifications for the *Saturn* facility, LOD officials said, architectural and GSE design work will begin. Contractors may be asked for proposals late next year. No one contractor is expected to get the GSE work.

This fast schedule will not apply to the launch pads for the giant *Nova* booster which will develop a total first-stage thrust of from 12 million to 20 million lbs. thrust.

Total cost of three *Nova* pads will be well over $500 million and may approach $1 billion. Each pad will be capable of eight launches per year.

The *Nova* gantry for each pad will be 450 ft. high and 20 ft. square at the base. The vehicle will be assembled and checked out on the pad. Because of the gantry's immense size, it will be immovable; the booster will have to be fired through it. The gantry's sides will be lowered to permit exhaust gases to escape.

The vehicles will be moved to the gantry on large barges which will also be used as the launch pad. Upper stages will be transported by rail and a crane will be used to place them on the first stage.

• **Spaceport buildings**—Besides the electronic GSE which will be needed for both launch complexes, liquid hydrogen-liquid oxygen storage tanks with a capacity of 500,000 gallons each and facilities for such high-pressure gases as helium and nitrogen will be needed.

The launch pads are only part of the story. Other buildings—requiring millions of dollars of equipment and instrumentation—which will be built at Cape Canaveral include:

—An engineering and administrative building.

—A spacecraft assembly building which will be able to assemble and check out two *Apollo* spacecraft at one time.

—A building to be used for the testing of various explosives used in the spacecraft system.

—Quite possibly, a cryogenics man-

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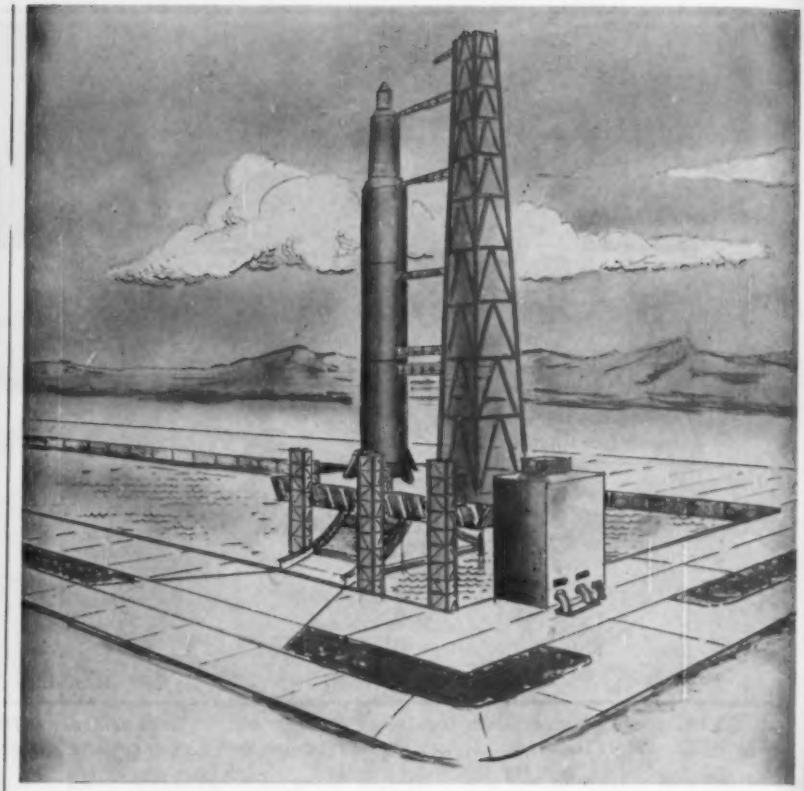


LOD'S CONCEPT of how a barge would be used to launch a Saturn C-4. The barge transporter under consideration would be 150 ft. long and 110 ft. wide.

ufacturing and storage building.

In addition to the vast GSE procurement and launch pad construction, LOD's other main function—besides the launching of vehicles with their payloads—will be in the area of research and development.

Among the major areas and problems which will be explored are:

—Better ways of receiving data from the booster before and during launch.

—Use of a water injection technique to cut the terrific noise level problem for instrumentation and equipment which will result from the *Saturn C-4* and *Nova* development.

—Better firefighting methods during launch operations.

—Problems in swinging and moving the heavy masses of the umbilical tower on the *Saturn C-4* pad.

—Blast effects of liquid hydrogen-liquid oxygen and similar studies of RP-1 and liquid oxygen.

—Making canal transportation smoother.

—The problems of long-distance digital transmission from the vehicle to the Vertical Assembly Building.

LOD's primary role is to provide the launch capability for the Marshall Space Flight Center. It also makes design inputs when the launch range limitations may influence a launch vehicle configuration, and provides support services for other NASA installation personnel who are working at the Cape.

LOD's director is Dr. Kurt Debus, whose official title is Director of the Marshall Space Flight Center's Launch Operations Directorate. He reports directly to Marshall's director, Dr. Wernher von Braun.

Debus' chief assistant is Dr. Gruen. Major Petrone is responsible for LOD's manned lunar landing activities.

An organization chart for LOD is not available at this time, because it is undergoing revision.

There has also been some consideration of a proposal to make LOD a self-supporting center which would report directly to NASA headquarters.

Best bet is that LOD will be relieved of its current responsibility for the construction of facilities to be used by personnel from other NASA centers. Instead, the various centers will be responsible for their own construction at Cape Canaveral, with LOD having master planning control.

At the Pacific Missile Range—which LOD also runs—the construction authority probably will be given to the Goddard Space Flight Laboratory. ⌗

Wallops to Grow Slightly—If at All

WALLOPS STATION — NASA's launch site for most of its sounding rockets and small scientific satellites—will be only marginally affected by the expansion of the overall space program.

Following the limited expansion programed for this fiscal year, the overall budget of Wallops should remain relatively constant and may actually decline as presently planned facilities are finished.

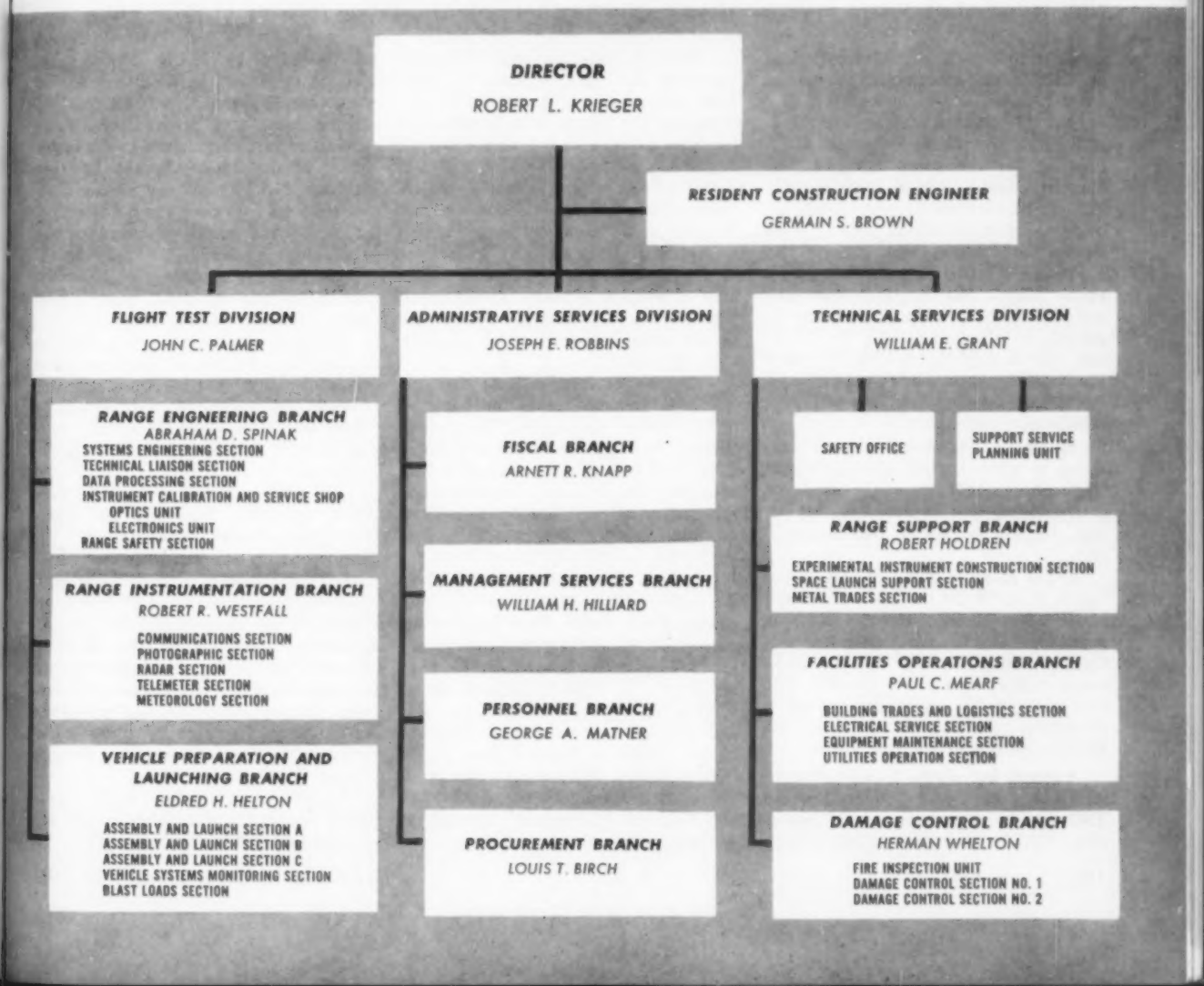
In terms of procurement dollars, this NASA facility presents little potential to industry. All of its contract awards are on a fixed-price basis and consist of well-defined, specified electronics systems or housekeeping services.

To fulfill its mission of launching scientific experiments and gathering data from these payloads, Wallops has a total Fiscal Year '62 budget of approximately $14 million. Of this, $3.8 million is for salaries and expenses, $4.0 million for support of the plant and operations and $6.3 million for updating and construction of facilities. The total complement for the station is scheduled to increase during this fiscal year from 299 persons to 399. Much of this increase has already taken place and employment at Wallops stands at a little more than 346.

• **Facilities available**—Wallops Station actually consists of three separate pieces of real estate. The first is the Main Base—formerly the Chincoteague Naval Air Station—housing the administrative and management groups as well as those technical services and shops not essential to launch operations. Also in this area is a prototype *Mercury* tracking station and the East Coast readout station for the *Tiros* meteorological satellites.

On approximately 100 acres of the mainland opposite the Wallops Island launching facilities are three 60-foot antennas. Two of these are operated by the Massachusetts Institute of Technology for studies of re-entry physics. The third—operated by Wallops personnel—is used to track the scientific payloads launched from Wallops Island.

Located on a sandy island off the Virginia coast are the five launch areas, the assembly and checkout buildings and the requisite blockhouses. At the southern limit of the launch area is the launch area and associated facilities for firing the *Aerobee*. Moving north, the next area consists of five extremely simple



launchers for small probe rockets, ranging from a 5-stage rocket system using an *Honest John* motor for the first stage to a small rocket for launching models.

Probably the most elaborate and expensive facility is the *Scout* launch area with its 105-foot, enclosed gantry and reinforced concrete-earth blockhouse.

The two remaining launch sites—*Little Joe* and *Trailblazer*—consist of simple concrete pads, fixed camera locations, terminal power and communications facilities and the launchers themselves. The *Scout* blockhouse is equipped to check out, monitor and fire vehicles from these pads.

• **Programs, present and future**—Since Wallops does not originate any programs, it is primarily concerned with updating and keeping in good repair the launch facilities necessary to satisfy user requirements. During the current fiscal year, for example, approximately two-thirds of its construction money will be spent to update its tracking facilities to meet the demands for near real-time data display. This improved tracking capability will increase the reliability, performance, precision and range of the existing AN/FPS-16 and Mod II radar tracking systems.

• **Procurement policy**—A fixed-price contract policy is possible, according to Wallops officials, because procurement is based on general performance specifications for a specific piece of equipment or on past experience with range service requirements.

The main areas of procurement interest are electronic equipment, particularly digital systems, electronic parts and repair and housekeeping services essential to the Wallops mission. Louis T. Birch is the station's procurement officer.

A firm interested in doing business with Wallops, according to station officials, should first write to Wallops outlining its capabilities and areas of interest. Then fill out a standard NASA Form 129 to apply for inclusion on the bidders' list and, finally, since Wallops has a limited procurement staff, make an appointment to visit the installation. ¤

NASA INDUSTRY GUIDE

PMR Has Modest Launching Program

Bulk of Test Support Office's $1-2-million FY 1962 budget is earmarked for a new Scout site; small staff plays important role in coordinating numerous phases of missions

ONLY A VERY SMALL portion of NASA's total space activity is carried on at the Pacific Missile Range.

Just 11 NASA launchings are scheduled from this facility through 1964. Funding for the space agency's Test Support Office (TSO) at PMR for FY '62 will be between $1 and 2 million, mostly for construction of a *Scout* launch site at Point Arguello.

NASA's entire plant investment at Point Mugu and Arguello currently amounts to about $3 million. Some expansion is indicated for the new *Scout* site. Also at Arguello, NASA will spend about $325,000 to modify a portion of the missile assembly building for space vehicle applications.

Another $300,000 will be spent modifying a *Thor* launch site (75-1) at Vandenberg AFB, formerly used for crew training and *Discoverer*-series firings, for use in NASA *Thor-Agena B* tests.

Other major existing NASA installations at PMR are the *Tiros* command and readout station; *Mercury* tracking station at Kokee Park, Hawaii, and Canton Island; and the *Mercury* command station at Point Arguello. The latter installation represents about a $1-million investment, including an FPS-16 5000-mile tracking radar.

• **Small but vital**—Though small in staff (11 persons) and in budget, the TSO acts in support of several important NASA programs. First NASA launch from PMR was *Nerva* (Nuclear Emulsion Recovery Vehicle) in 1960. Most recent was the successful *BIOS I* launching this month. Firings scheduled for TSO support in the future include Projects *Nimbus* and *POGO*, and second-generation *Echo* satellites—all involving the *Thor-Agena B* combination.

For most launches, a specialized team is sent on temporary assignment to augment the small TSO staff. In the case of Project *Mercury*, for example, a seven-man team from the Space Task Group monitors operation of the *Mercury* installations.

TSO is not independent—the staff is directly responsible to the Marshall SFC Launch Operations Directorate. Systems manager for TSO at PMR is Cdr. S. J. Burttschell, a Naval aviator with considerable missile experience on assignment to NASA. Cdr. Burttschell is responsible for final coordination of all NASA launch activities at PMR.

Because of its close ties to Marshall, the support office makes few local purchases. PMR makes those that do not exceed $25,000. Whenever possible, major facilities are authorized by Marshall or directly by NASA headquarters, in accordance with PMR's master plan and multiple-use concept. Contracting of this nature is handled through the Navy's Bureau of Yards and Docks.

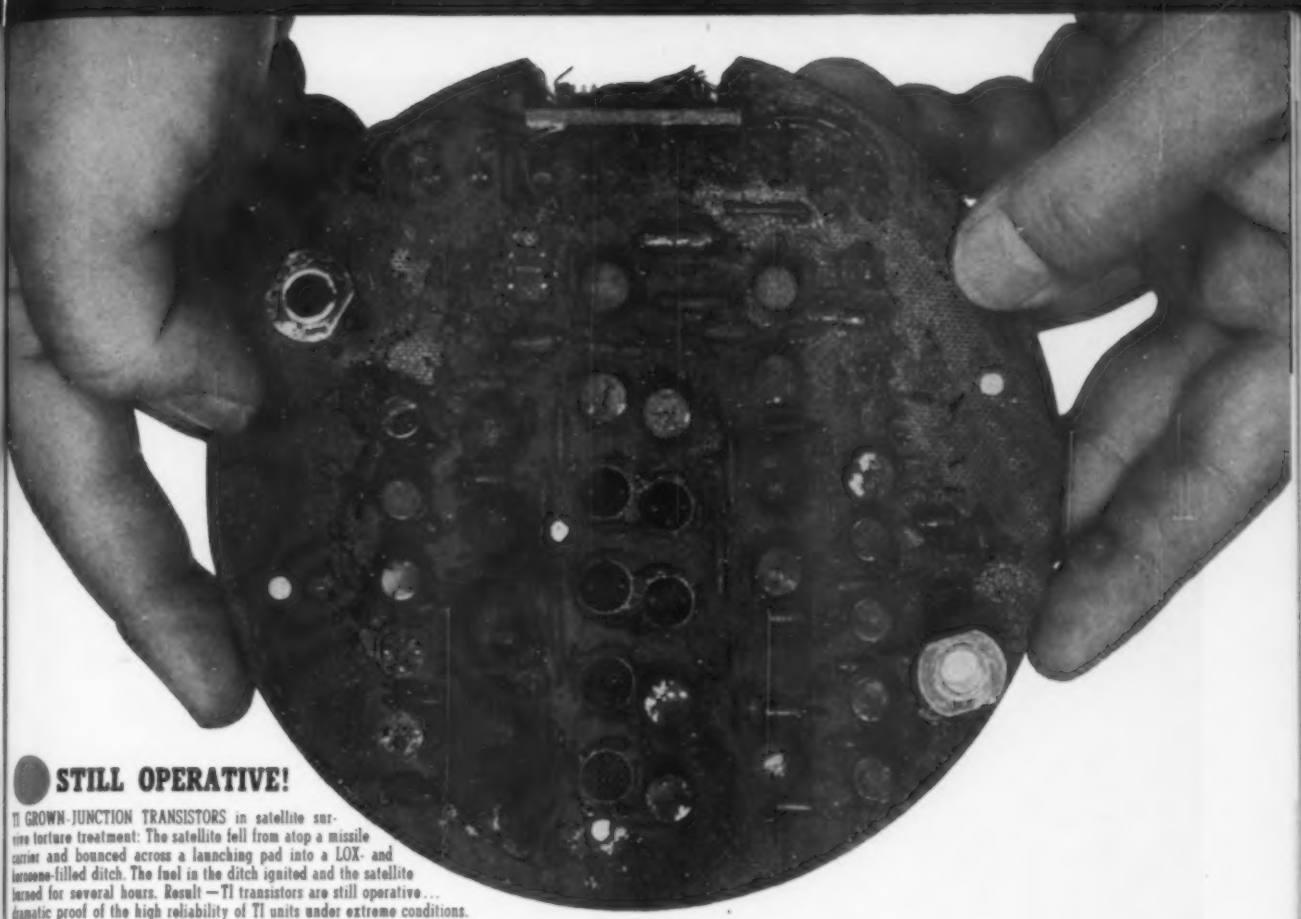
A major problem for TSO/PMR and Marshall is formation of program decisions within the normal budget cycle of PMR. When NASA requirements can be delineated in time, the needed funds can be included in PMR's budget. In the event of a program change or special requirement (such as the installation of the Point Arguello *Mercury* station), NASA must pay for the facility from its own program funds.

• **Prime example**—Perhaps the best illustration of TSO functions was the recent *BIOS I* launching. In this shot, the TSO was involved with almost every major NASA division.

Project management was the responsibility of Goddard SFC; bioscience system management by Ames Research Center; physical science system management and launch vehicle system management by the Launch Operations Directorate, Marshall SFC.

To further break down this "one-shot" operation, there was also direction from NASA headquarters. The Office of Life Sciences Programs established requirements for *BIOS* and overall project direction. The Office of Space Flight Programs implemented the program through Goddard. The Office of Launch Vehicle Programs implemented launch, tracking, and recovery operations through Marshall, and the Office of Advanced Research Programs implemented bioscience experiments through Ames.

Actual coordination of all program phases for mission execution was handled by TSO. ¤



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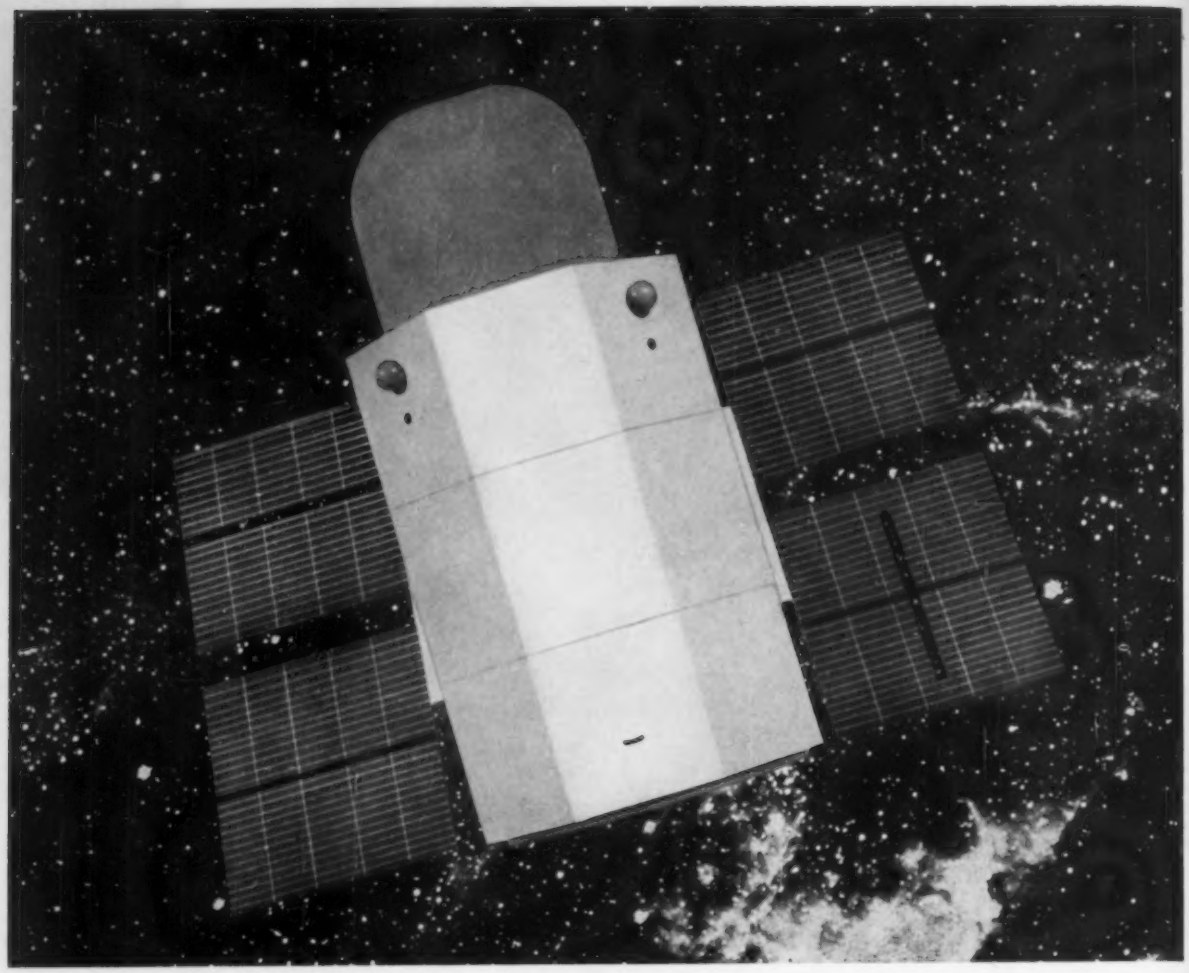

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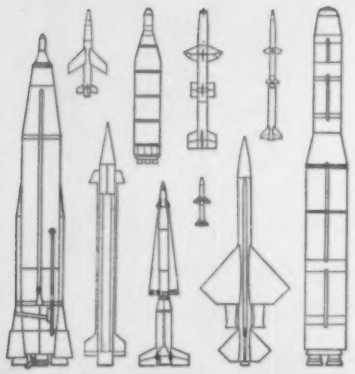

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NEW ADDITIONS

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	Alloy Name	NOMINAL CHEMICAL COMPOSITION										
		C	Mn	Cr	Ni	Co	Mo	W	Ti	Al	B	Fe	Others
Fe-Base	19-9DL	.30	1.0	19	9	..	1.4	1.3	.3	...	...	66	.4 Cb
	19-9DX	.30	1.0	19	9	..	1.6	1.3	.6	...	...	66	.....
	AF-71	.30	18	12.5	...	..	3	...	...	...	.2	73	.2N, .9V
	A-286	.05	1.4	15	26	..	1.25	...	2.2	.2	.003	54	.3 V
	Discaloy	.05	.6	13	26	..	3	...	2	.2	...	54	.....
	G-192	.60	8.5	22	...	..	....	...	...	...	...	69	.35 N
	V-57	.06	.25	15	26	..	1.3	...	3	.2	.008	54	.2 V
Fe-Ni	D-979	.05	.6	15	45	..	4	4	3	1	.01	27	.....
	AL 901	.05	.25	13	43	..	6	...	2.9	.2	.015	35	.03 Zr
Ni-Base	Waspaloy	.05	.3	19	56	14	4	...	3.0	1.3	.005	1	.....
	M-252	.15	.5	19	55	10	10	...	2.5	1	.005	2	.....
	R41	.10	.3	19	53	11	10	...	3.2	1.6	.005	2	.....
Co-Cr-Fe-Ni	S-590	.43	1.2	20	20	20	4	4	...	...	...	29	4 Cb
	N-155	.15	1.5	21	20	20	3	2.5	...	...	...	32	1 Cb
Co-Base	S-816	.40	1.2	20	20	44	4	4	...	...	...	3	4 Cb
	V-36	.30	1	25	20	42	4	2	...	...	...	3	2 Cb
	L-605	.15	1.5	20	10	53	....	15	...	...	...	...	.....

A number of the names listed above are tradenames of companies other than Allegheny Ludlum Steel Corporation

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	Alloy Name	Density lb/in.³	100-Hr. Rupture Strength at (X 1000 Psi)				Short Time Properties					
			1200F	1350F	1500F	1600F	Room Temperature			1200 F		
							TS	.2YS	Elong. %	TS	.2YS	Elong. %
Fe-Base	19-9DL	.287	52	28	17	...	118	69	55	75	37	33
	19-9DX	.287	52	28	17	...	118	69	55	75	37	33
	AF-71	.280	69	40	22	...	150	110	30	90	77	43
	A-286	.286	63	35	15	...	152	110	25	115	87	25
	Discaloy	.288	55	32	15	...	147	92	20	100	77	18
	G-192	.278	42	27	15	...	148	85	55	92	37	15
	V-57	.286	75	40	15	...	172	119	24	129	108	22
Fe-Ni	D-979	.296	94	63	35	21	200	143	18	157	123	17
	AL 901	.294	90	60	20	...	175	125	15	145	110	20
Ni-Base	Waspaloy	.294	98	65	39	24	185	130	28	160	120	22
	M-252	.298	95	62	35	20	180	122	16	155	110	17
	R 41	.296	100	67	44	28	200	150	15	160	130	10
Co-Cr-Fe-Ni	S-590	.301	50	32	22	13	140	75	20	97	70	25
	N-155	.297	50	31	18	12	119	58	40	80	43	55
Co-Base	S-816	.313	60	38	25	16	140	72	35	115	55	27
	V-36	.303	64	35	25	18	145	67	55	95	40	28
	L-605	.330	70	43	24	15	150	70	50	98	48	28

Properties listed above are typical, and should not be used as specification minima.

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NOMINAL COMPOSITION OF MAR-AGING STEELS

	C	Ni	Co	Mo	Ti	Al	Cb
AL 25 Ni (250)	.01	25	..	..	1.4	.2	.5
AL 20 Ni (250)	.01	20	..	..	1.4	.2	.5
AL 18 Ni Co Mo (250)	.01	18	7	5	.4	.1	..
AL 18 Ni Co Mo (300)	.01	18	9	5	.6	.1	..

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PRODUCTS	.2 YS (X 1000 psi)	UTS (X 1000 psi)	Elong. %	RA %	Notch TS / Smooth TS
BARS (Heat treated)					
AL 25 Ni (250)	250	265	12	50	1.1
AL 20 Ni (250)	250	265	12	55	1.3
AL 18 Ni Co Mo (250)	250	265	10	50	1.5
AL 18 Ni Co Mo (300)	300	305	12	55	1.4
SHEETS (Cold rolled and aged)					
AL 25 Ni (250)	250	270	5	..	.7
AL 20 Ni (250)	260	270	4	..	.7
AL 18 Ni Co Mo (250)	285	290	4	..	.9
AL 18 Ni Co Mo (300)	300	310	3	..	.8

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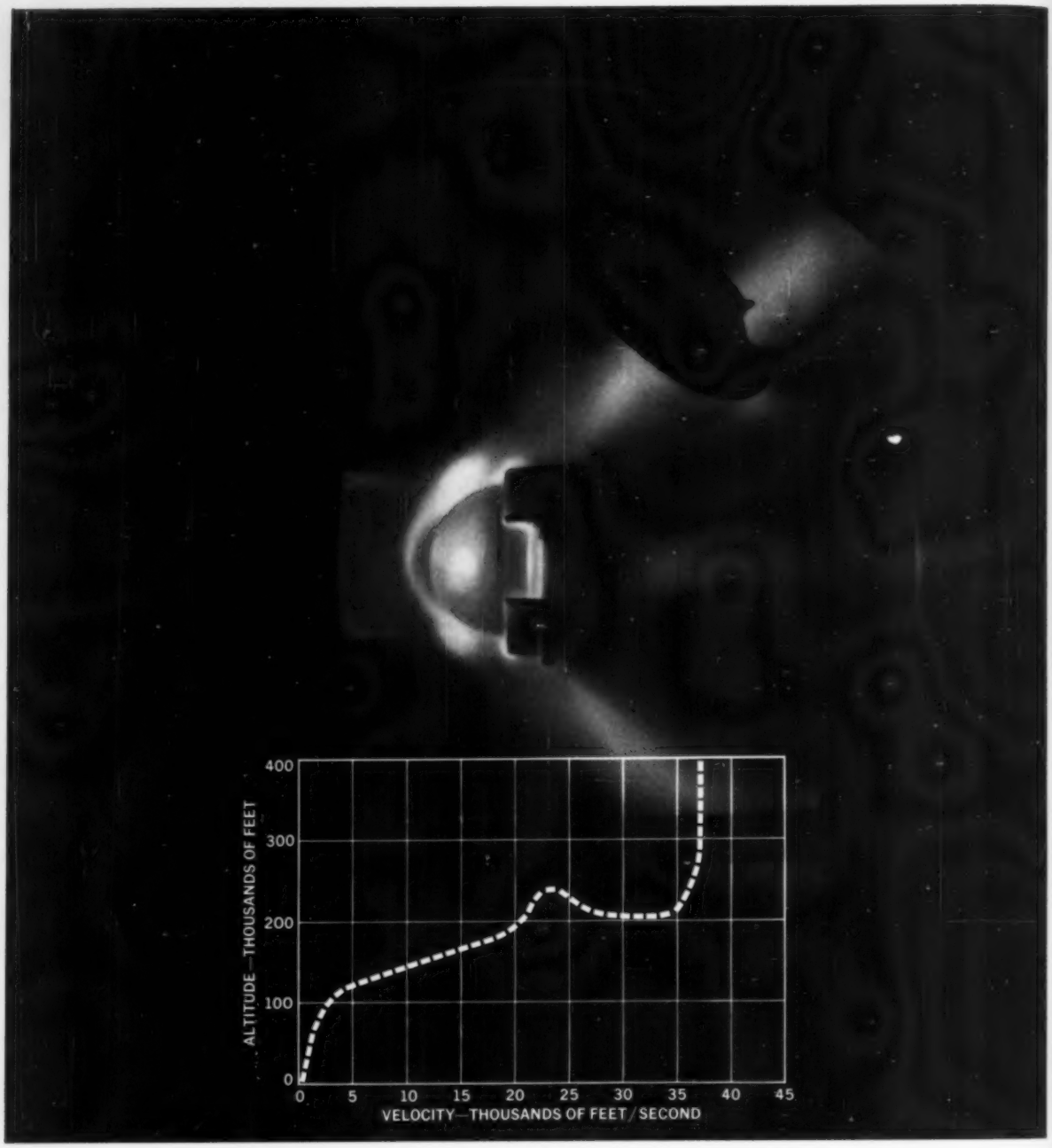

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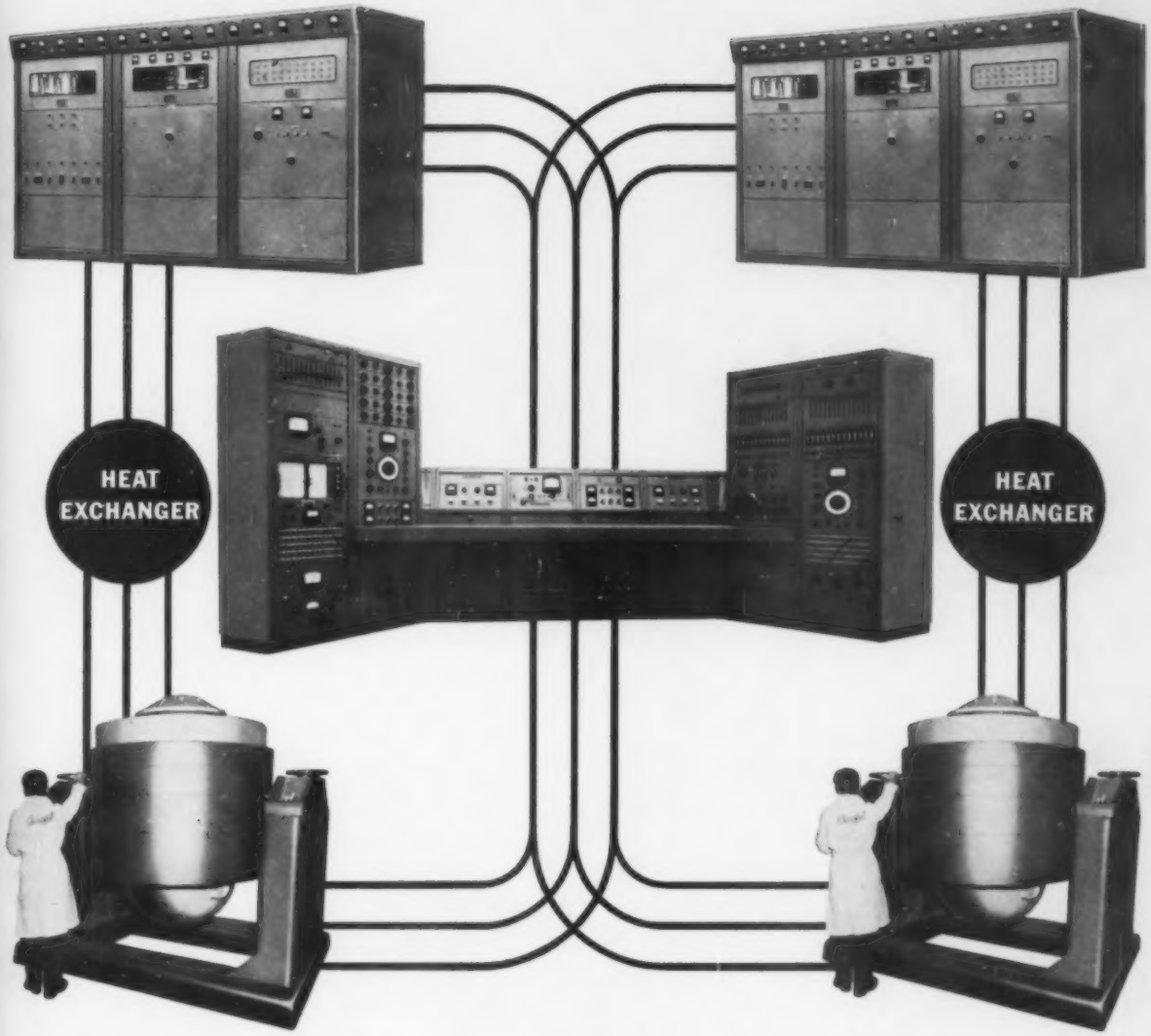

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Langley to Maintain R&D Leadership

MODERATE BUT STEADY expansion is the forecast for NASA's oldest research center, at Langley, Va.

Authorizations for plant modernization and new facilities over the Fiscal 1961-62 period total nearly $45 million. Improvements are expected to assure the center's continued leadership in materials and structures research and development for the space agency.

One-third of Langley Research Center's 3000-plus employees are scientists and engineers. Indicative of the in-house capability here is the relatively small outlay in contracts to industry for basic research—only $5 million out of a total of $60 million authorized for R&D. The rest goes for hardware procurement, including $30 million for *Scout* launch vehicles.

It is significant that Langley has served as a reservoir for highly skilled specialists from which the government has drawn over and over again to form new research facilities. Cadre for four research centers—Ames, Lewis, Wallops Station, and the Flight Research Center at Edwards AFB—were first provided by Langley.

Established nearly 45 years ago, this center has been involved with virtually every type of aircraft, missile and spacecraft built or presently conceived. When the first Mach-3 air transport or the *Apollo* or *Dyna-Soar* leaves earth, it will be due in no small measure to the research being performed here today.

• **Major programs**—By far the greatest research effort at Langley is the broad study of structures and advanced materials, a field in which it is considered the major NASA center. Scientists here wage a continuous many-pronged attack on high-temperature problems of re-entry.

In their Flight Re-entry Program, researchers will obtain flight verification of heating problems on typical lunar return vehicles. In general, the tests involved cannot be performed with ground facilities.

Five-stage *Scout* launch vehicles will be used to approach speeds up to 30,000 ft./sec. Three different payloads are now being built to study (1) total heat (convective and radiative), (2) separate radiative components, and (3) heat-shield materials.

FLOYD L. THOMPSON
Director of Langley Research Center

In cooperation with Lincoln Laboratory of Massachusetts Institute of Technology, the Center has been concerned for the past 2½ years with the Trailblazer program. Primarily, this is a signature study of ICBM trails during re-entry. The Trailblazer vehicle employs six stages—three for vertical boost upward, three for downward.

The program has been extended to relate mass and light intensity for media determinations up to 200 miles altitude.

Using the six-stage vehicle, velocities up to 23,000 ft./sec. have been achieved. A seven-stage vehicle also has been employed to fire a dime-size steel projectile to 37,000 ft./sec.

Other principal programs include:

—Development of the NASA *Scout* launch vehicle (since 1958).

—Design and development of *Echo* passive communications satellites. Follow-on to *Echo I* is the rigidized, 135-ft.-diameter *Echo II* now in final development. Langley is responsible for program contracting, as well as satellite and payload design.

—Coordination of instrumentation supplied by other NASA centers for the micrometeoroid-satellite program and for all the final payloads.

—Fundamental investigations of plasmas and plasma motions.

In addition to these and other smaller programs for which Langley has prime responsibility, the center also conducts basic research to support other centers.

• **Langley facilities extensive**—Over its 710 acres, Langley has planted more than $150 million worth of laboratories, shops, support facilities, and more than 40 major wind tunnels.

Ground facilities are supplemented by free-flight research facilities including use of full-scale aircraft and vehicles launched by rocket from Wallops Island on Virginia's Eastern Shore.

Tunnels range in size all the way up to one having a 30x60-ft. cross-section. Velocities obtainable vary from low-speed to Mach-30 in the Langley helium tunnel.

Hot-jet research facilities include one with a temperature capability reaching 16,000°F for re-entry simulation. A 10,000-kva power supply is used with the arc-jet systems.

A Langley-developed combined-loads machine is believed to be the only facility of its type in the world. It can apply combinations of loads and moments which include up to a 250,000-lb. axial load, 2.5 million-in.-lb. torsion load, and a 3 million-in.-lb. bending load.

Other major facilities include a landing-load track (for aircraft tests), vehicle control and lunar-landing simulators, and a 1.2-million-lb.-capacity hydraulic testing machine (for specimens up to 6 ft. wide x 18 ft. long).

Important new facilities authorized or in design and construction include:

—A Dynamics Research Laboratory (to study dynamics problems on boosters, spacecraft, etc., under true environmental conditions).

—A Hypersonic Aerothermal Dynamics Facility (to study hypersonic aerodynamic and aeroelastic problems under conditions of extreme temperature and velocity.

—An 8-foot-high, 4000°F temperature, Mach-7 structures research tunnel (to study problems of large test specimens under combined influence of aerodynamic loads and high temperature).

—A Lunar Landing Research Facil-

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ity (to study stability, control, and instrument display problems of a man landing on the moon).

—A High-Intensity Noise Facility (to study the effect of noise on structures such as boosters).

—A Magnetoplasmadynamics complex. This includes a 10-megawatt arc tunnel now under construction that varies from 6 to 24 in. in diameter over its full length and will be capable of velocities as high as Mach 8.

Comparison of Expenditures by Langley Research Center for Fiscal Years 1961-62.

	'61	'62	Change
	(millions)		
Operating Costs (Salaries, etc.)	$30.4	$33	+$ 2.6
R&D contracts	46.8	60	+ 13.2
Facility construction contracts	24.8	20	— 4.8
TOTAL	$102.0	$113	+$11.0

• **Organization and responsibilities**—Organizational structure of the Langley Research Center resembles that of a centralized industrial complex. Functionally, it is comparable to a typical industry research and development operation.

Director Floyd L. Thompson has two senior assistants, C. J. Donlan and L. K. Loftin, Jr. His office is also supported by the usual senior scientific, technical and administrative staffs.

Five major functional groups, consisting of 18 operating divisions, comprise the principal structure at the Center. In addition, three special projects—*Scout* development, Flight Re-entry, and Cooperative Projects—answer directly to Thompson's office.

The five major groups include Administrative Services, Technical Services, and three distinct R&D groups.

Project engineers for almost every task performed at the Center are drawn from the Engineering and Electrical Divisions of Technical Services. Prime concern of the Engineering Division is the engineering and design of research models and vehicles, research facilities, mechanical and chemical systems and controls. Electrical Division is concerned with electrical/electronic systems and subsystems design and engineering.

Each of the three R&D groups embraces three divisions and is headed by an assistant director.

The first, under John Stack, includes the Aero-Physics, Full-Scale Research, and Theoretical Mechanics Divisions. Principal efforts at Aero-Physics are in the areas of hypersonic vehicle performance, control, and stability; heat transfer and fluid dynamics; propulsion gas dynamics; magnetoplasmadynamics; space physics, re-entry phenomena and energy management, and advanced vehicle and mission analysis.

The evolution, improvement, and characteristics evaluation of aircraft, missiles, and spacecraft configurations and components are the domain of Full-Scale Research Division. Specialists here are particularly concerned with lift, drag, moments, static and dynamic loads, and aerodynamics of propulsion.

Stack's Theoretical Mechanics Division actually is split into two branches—astromechanics and mathematical physics. The first studies problems in navigation, guidance and control of both manned and unmanned spacecraft for lunar and planetary missions. The second is a small band of highly specialized scientists working on very fundamental problems in aerospace technology—such as the nature and influence of solar radiation fields, re-entry dynamics, and the nature of the lunar environment.

The second functional R&D group is directed by Eugene C. Draley and is concerned primarily with structures and materials research.

His Applied Materials and Physics Division covers a variety of studies of material problems in space. These include *Apollo*-type re-entry, free flight research, study of ionized flow fields (problems associated directly with radio-propagation attenuation and radar identification and tracking), meteoroid hazards, and large erectable space stations.

The Dynamic Loads Division is developing analytical and experimental methods for predicting and alleviating dynamic loads and aeroelastic instability phenomena on high- or specialized-performance flight vehicles. Scientists here also are investigating acoustics, landing and impact, vehicle dynamics, vibration and flutter.

Draley's third division is responsible for Structures Research. Its staff devotes its attention to weight and reliability characteristics of structures and materials in space vehicles and aircraft.

The last of the three R&D groups is under the direction of Hartley A. Soulé.

Guidance, stability, control, operating problems, and recovery techniques and systems in air and space are investigated by the Aero-Space Mechanics Division. Considerable emphasis is placed by the scientists on effective integration of man/machine systems. All types of booster and spacecraft recovery systems also are now under study.

A second division in the group is concerned with Analysis and Computation for the Center. Employing IBM 7070 and 7090 high-speed digital computers and plotters, the unit performs all

necessary advanced mathematical computations and simulations for the other R&D divisions. It also handles tape storage and data retrieval.

The Instrument Research Division completes Soulé's group. It has responsibility for development and construction of electrical, mechanical, optical, and electronic instruments vital to aerospace research.

• **Contracting procedures** — Obviously, contracting and purchasing procedures are defined by Federal law. Within the framework of these provisions and regulations, Langley procurement is handled as follows:

Key procurement and contract negotiation officers include:

—Sherwood L. Butler, Procurement Officer.

—John Munick, Assistant Procurement Officer.

—Willis A. Simmons, Chief-Contract Negotiation and Administration Branch.

—William B. Hutchesan, Chief-Purchase Branch.

Formal advertising for competitive bids is employed particularly for purchase of supplies, materials, equipment, and construction when these items can be clearly defined by specifications and/or drawings.

When this is impractical—in R&D contracts, for example— procurement is made by negotiation with firms on a qualified bidders list in the desired purchase category.

Technical direction, including project officer supervision, is provided by Langley for all prime contracts under its cognizance. It also employs its own contract-negotiation and administrative staff.

Prime contracts are negotiated directly with the contractor. Langley does, however, retain a flexible procedure in contract administration; it uses either its own staff or the services of the Department of Defense or other government agencies when this is deemed necessary.

Simmon's group handles contracts for R&D procurement by negotiation; Hutchesan's group handles advertised contracts.

In the past, Langley has not made use of the "Quick-Reaction"-type of contracting procedure (QRC) used so effectively by the military. During the past year, however, the Center qualified its first contractors. Others, Langley officials say, will be qualified for different technologies or services.

The first contractor qualified was in the field of optics—the J. W. Fecker Division of American Optical Co. The arrangement with Fecker is in effect an open-end R&D contract—contracts valued at $100,000 or less will be issued like a simple purchase order.

(Continued on page 136)

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(Continued from page 135)

Two other contracts will soon go into effect: one for analog-simulation services and the other for architecture and engineering services (for facilities on the station).

• **Information exchange**—The interchange of ideas and scientific and engineering advances in any organization is of major importance. In the vast nationwide complex of NASA installations, the problem is inherently difficult.

At Langley, all the standard methods of data exchange are employed. These include:

—Broad dissemination within and without of all formal NASA-originated technical reports and of all other pertinent formal reports issued by other Federal agencies, educational institutions, etc.

—Contributions to and attendance at appropriate technical conferences and symposia by as many Langley personnel as practicable within budget limitations.

—Similarly, visits by as many key personnel as possible to other NASA centers and industrial complexes. At the same time, the center encourages visits by others to Langley, to promote the exchange of ideas and advance technologies.

Because of the complexity of the task, information flow for the *Apollo* program will be handled through implementation of the *Apollo* Technical Liaison Plan, of which Langley is a part. Essentially the Plan involves systematic liaison between all associated NASA centers and outside organizations involved in the program.

Liaison groups in which Langley has primary interest have been formed for technical areas — including trajectory analysis, configuration and aerodynamics, guidance and control, heating, structures and materials, instrumentation and communications, human factors, mechanical systems, and onboard propulsion.

Langley officials expect to reap many advantages from the Plan. They have five main objectives:

1. To keep an up-to-date summary of all technical activities pertinent to each Center.

2. To summarize and disseminate all R&D projects and results as soon as possible.

3. To have a vehicle for the reporting of contractor activities to all group members.

4. To create a mechanism for solution of major technical problems as they arise.

5. To unearth problems and needed research areas before they become bottlenecks in the program.

• **Expenditures up**—Fiscal '62 expenditures by Langley are expected to reach $113 million. This total includes salaries and expenses for the operation and maintenance of the entire Center, R&D contracts, and facility construction contracts. It also covers the cost of managing some activities of other NASA centers and government agencies. (For example, Langley manages the establishment of the Project *Mercury* ground instrumentation and tracking network for Goddard Space Flight Center.)

The $113 million outlay is $11 million, or about 10%, higher than expenditures in FY '61.

The accompanying table provides a comparison of spending in the two years. While salaries and expenses show modest increase, costs for R&D have climbed over 25% in one year. New facility costs have dropped nearly $5 million, as construction slowly catches up with building requirements.

Personnel needs at the Center are expected to bring in an additional 400 persons, for a total of 3628, by next July. The new employment will be principally for administrative support rather than for scientific or engineering activities.

• **R&D contracts**—A close look at the funds to be expended during FY '62 for R&D reveals that the most of the $60 million will be allotted for hardware and materials.

Langley officials told M/R that half the total funds available will be used to purchase *Scout* launch vehicles. About $25 million will go for supplies, materials, and equipment needed to support in-house R&D programs. The remaining $5 million will support industry contracts for basic research.

• **Looking ahead**—The future for NASA's senior laboratory undoubtedly will match its long past, during which it has continuously been in the center of aviation/missile/space history.

Langley can trace its involvement in the missile field from its early experimentation in 1918 with the Navy's Aerial Torpedo—a modified Curtiss-Wright aircraft used as a drone carrying a 1000-lb. explosive package—down to its current research on para-gliders, *Dyna-Soar*, *Apollo*, and the Mach-3 air transport.

NASA Administrator James E. Webb stated recently that current expansion of the Center is only the beginning. During this fiscal year alone, over $20 million is authorized for expanding and modifying old facilities and building new ones.

A vital part of NASA's vast but still growing in-house scientific capability, a major center of materials and structures research, Langley will continue to advance the U.S. missile/space effort. ⌗

Lewis May Drop In-House Tradition

SOME MAJOR changes may be in the wind for NASA's oldline propulsion research facility—the Lewis Research Center.

Current indications include:

—A better than 20% increase in technical personnel.

—Shifting of all NASA space electrical propulsion to Lewis.

—Appointment of Dr. A. Silverstein, former chief of NASA Space Flight Programs Office, to be director of the huge Center.

—Addition of a new arm in the Procurement Section at Lewis, an assistant for Development Procurement, and an increase of between 30 and 40 people throughout the entire section.

While no official statements have been made, it is entirely possible that a fairly large development effort will be handled by the center, beginning sometime during the next 18 months.

This means Lewis might break sharply with its past tradition of emphasizing in-house research, a tradition which has been maintained even though industry-contracted projects have been slowly increasing.

An increase in development activity, especially in certain segments of the *Apollo* program and electrical propulsion, has led to speculation that Lewis might be in the $400-million category—including all center activities. But this dollar figure is labeled "fantastic" in some quarters.

• **Current expenditures** — Lewis is currently working with a budget in the neighborhood of $55 million, about $25 million of which will be spent in Fiscal 1962. Salaries and other items account for approximately $30 million. Large construction and major equipment requirements will gobble up 60% of the remaining $25 million.

Construction is announced almost entirely by formal advertising. Standard government procedure is normally used: a 30-day bid time, a formal opening, and an award to the low bidder under a straight-fixed-price contract.

Lewis currently looks for contractors capable of earmarking requirements and giving 5-to-10-day delivery on whole classes of housekeeping items.

DR. ABE SILVERSTEIN

Major development assignment in works?

So far, not many research and development jobs are available. But contracts for R&D of propulsion systems, materials, cryogenics and gases are increasing in number. They are usually negotiated and cost-type.

Lewis' key purchasing men are J. R. Biggs, Procurement and Supply Officer; J. H. Zimmerman, chief, Purchase and Contracts Branch; and N. C. Prahst, Small Business and Contracts Relations.

Small business possibilities are good. Last year 70% of all business and 40% of all contracts over $2500 landed in this area. Major equipment purchases in the latter category will be heavy in 1962.

• **Procurement setup** — The main elements of the Procurement and Supply Division at Lewis follow, together with their personnel and areas of responsibility.

The General Contract Section purchases research and development and other major items. L. P. Kelley heads the section and specializes in price and cost analysis, major negotiations, consultant services, research and development, cryogenic and high-vacuum equipment. B. Torre handles mechanical, hydraulic, and pneumatic pumps, major electrical and electronic systems.

W. Park covers instrument repair, laboratory equipment and some special projects procurement while L. Goulden covers special projects procurement.

The Construction and Contract Services Section is run by R. W. Bouman, who is also responsible for building and facility construction and architect-engineer services. S. Maun and W. Colli handle repairs, maintenance, new construction and alterations.

The Small Purchase Section buys minor equipment items, stock, operating supplies, fuels and fuel-handling equipment. Section head is G. J. Widra, who also specializes in gas-transport equipment, cryogenics and gaseous propellants.

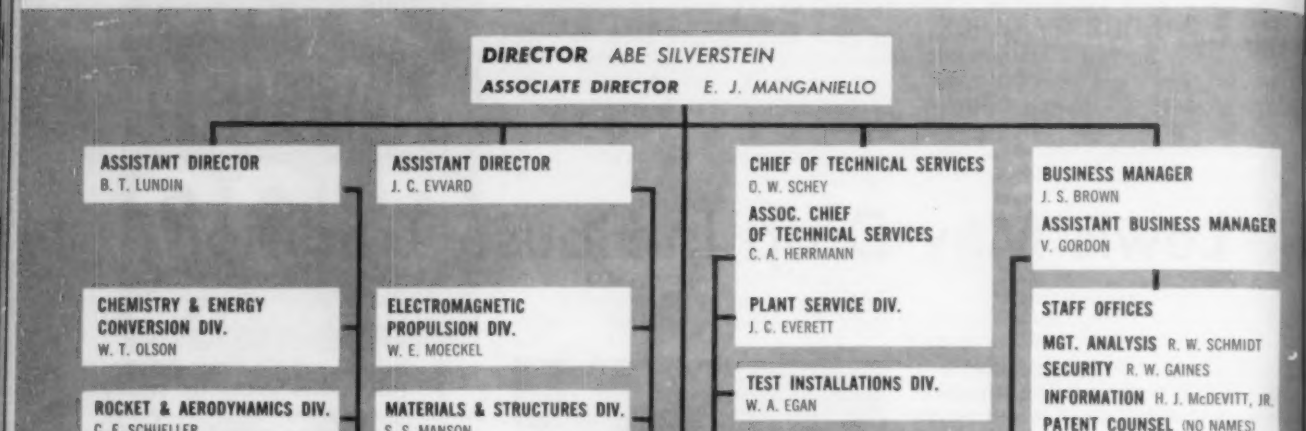
E. L. Kozar buys mechanical equipment and supplies; A. Krismanth handles chemicals, fuels, lubricants, coatings, cutting tools and radio-active materials; W. T. Hodges buys base metals and photographic supplies; I. Nelson specializes in hardware, mill and medical supplies and F. R. Riedel handles electric, electronic parts and aircraft fittings.

The Contract Administration Branch, under J. M. Katzman, handles all modifications to current contracts, regardless of commodity.

• **Interlocking divisions**—The Lewis Research Center is NASA's principal propulsion facility. It covers 350 acres adjacent to the Cleveland Hopkins airport, with additional research reactor and rocket installations at the 6000-acre Plum Brook section, Sandusky, Ohio. Total personnel is around 3000, with an additional 600-plus to be hired in the current NASA recruiting drive.

The center has eight basic operating divisions with the usual support, financial, and administrative sections. The Plum Brook reactor facility is now under the Nuclear Reactor Division, but it will shortly be established as a separate operating entity.

There will probably be some shifts in the directorate setup at Lewis as a result of the recent appointment of Dr. Silverstein to the top job. But it is not expected that the basic areas of interest within the current divisions will be



changed to any great degree.

The divisions are interlocked to support each other's particular abilities. Thus evaluation and fundamental work go hand in hand through the center as projects are generated, pursued, divided or dropped.

The key activity is research: this theme penetrates every corner of Lewis. From time to time applied and development tasks are picked up here and there, mostly because of the nature of current equipment and/or the particular abilities and experience of individuals. Lewis is not widely known for following programs through to production.

• **Fundamental probing**—The Chemistry and Energy Conversion Division, headed by W. T. Olson, covers a broad range of physical chemistry investigations and the direct conversion of radiant energy to electricity. In the latter area, about 25 scientists are probing thermionic, thermoelectric and photovoltaic problems with some emphasis on the thermionic—considered to be a pay-off area over the long run.

A new million-dollar laboratory is being finished and installation of over $1.5 million worth of equipment has started. The energy conversion lab will have simulated energy sources for evaluation purposes, high-vacuum equipment, zone refiners, crystal-pullers, melting furnaces and physical measuring instruments (see NASA Materials Section, p. 68).

On the physical chemistry front, the division has a machine program in the thermal and transport properties of gas and gas mixtures. The program takes inputs of gas and temperature and feeds out thermal data. A thorough set of internally consistent data has been generated.

Recombination rates of atoms on different surfaces are being studied. Methods of computing viscosity and thermal conductivity of a gas, gas mixtures and reacting mixtures are being investigated. In general, the work here covers any application of hot gases and is definitely fundamental.

Fully half the division is engaged in rocket combustion chamber work—both liquid and solid. For example, combustion studies in liquids involve the steady-state combustion of propellants and how to take advantage of the well-known "screaming process" in a liquid engine.

Solid-propellant work includes operational flexibility, re-ignition and some investigations of the nature of the burning process.

A large amount of work in heat transfer is also conducted here. This aspect covers both the hot and cold gas sides of the problem. In the hot area the main question is one of rate—how fast to remove the heat. Pipe flow equations do not apply to nozzle configurations; Olson's group is looking for equations that will work here.

On the cool side—the cryogenic area—the problems are extremely complex. Investigators are working with liquid gases near their critical points—where small temperature variations produce rapid property changes.

The division is monitoring several outside contracts. One, with Pratt & Whitney, is for a model of a fuel cell powerplant, which it is hoped will be a forerunner to a useful *Apollo* system. Another award, to Stanford Research Institute, is for an assessment of NASA needs for high-energy propellants in future programs.

Some smaller contracts are out—

including one to Warner and Swasey's Research Labs to develop a method of measuring temperature and composition through infrared techniques.

The Rocket and Aerodynamics Division, under C. F. Schueller, handles all the wind tunnels at Lewis. The tunnels have been involved in *Saturn* base heating studies and efforts are under way to correlate this data with that from other NASA centers and the actual flight information from the Cape. This work was carried out in the 8-by-6-ft. Supersonic Wind Tunnel with small-scale operating models of the *Saturn*, including several modified for *Apollo*. The center also has a 10-by-10 ft. Wind Tunnel.

• **Into fluorine**—Altitude performance characteristics of the *Centaur* engine, including controllability, are being evaluated at this division. Lewis is running one barrel but simulating the second through a loop system to investigate unequal operation.

In the category of general research, studies into the ignition of high-energy propellants are being carried out. The division has been in the high-energy area, including hydrogen-fluorine, for over 5 years. The work is aimed at future large-velocity-increment missions and includes injector designs, performance, control requirements, cooling and all the aspects usually associated with a general rocket program. Pressurized HF systems are used on stands and in altitude chambers originally built for turbo- and ramjet-engine studies.

In this division there is also a mission analysis group whose prime function is to outline research problems to provide general guidelines for research direction at Lewis. The group raises questions in atmospheric braking, powerplant sizes, vehicle layout concepts and other areas. The constant progress across the country means this group is constantly revising old problem areas or generating new ones.

The Nuclear Systems Division, under the direction of D. S. Gabriel, handles the NASA-Lewis efforts in *SNAP-8*, *Rover* and the zero-gravity work on liquid hydrogen storage and cycling.

The nuclear rocket work is highly classified but the systems division handles such problems as:

—Contract responsibility for long-period testing (wind tunnel conversion).

—Experimental heat transfer work, flow stability, start-up cycle.

—Hazards associated with flying reactors and the type of ground facilities needed as the program develops.

—Investigations on follow-up programs beyond *Rover*.

There are several other areas, and the division is also called upon to supply contract monitors. In addition, some problem areas are passed on to other divisions at Lewis for solution. Generally, the division supports the nuclear rocket with the exception of the reactor.

Power programs in the division include *SNAP-8*, *Sunflower* and about a dozen other contracted efforts in advanced research. A certain amount of support work on *SNAP-8* is carried out at the center. The *Sunflower* project is almost entirely contracted, but the division expects to have a greater in-house program in the near future.

The Fluid Systems Division under I. I. Pinkel has two general areas of interest—propellant system components such as pumps, tanks, valves, etc., and space power components.

Propellant component research digs into the pump design for cryogenic F_2, H_2, and O_2 systems. The group studies novel approaches—such as multi-stage turbines with a single-rotor disc.

The insulation problems connected with cryogenic tanks being stored or used a long time in space are part of the work here. The messy heat transfer problems in this area become quite complex (see NASA Propulsion, p. 62).

Space power components mean involvement in liquid metal systems. This part of the division's research work moves into zero-gravity environments and the headaches associated with phase separation under such conditions.

Pinkel's people worry about the degradation of radiators with respect to time, heat rejection and circulation problems. In addition, the division supplies teams for such current projects as the F-1, J-2 and *Centaur*.

Pinkel says Lewis is no longer self-sufficient in the fluids area. There is a growing need for a "satellite" industry, but division personnel try to stay with those problems that lead to deeper understanding of the field.

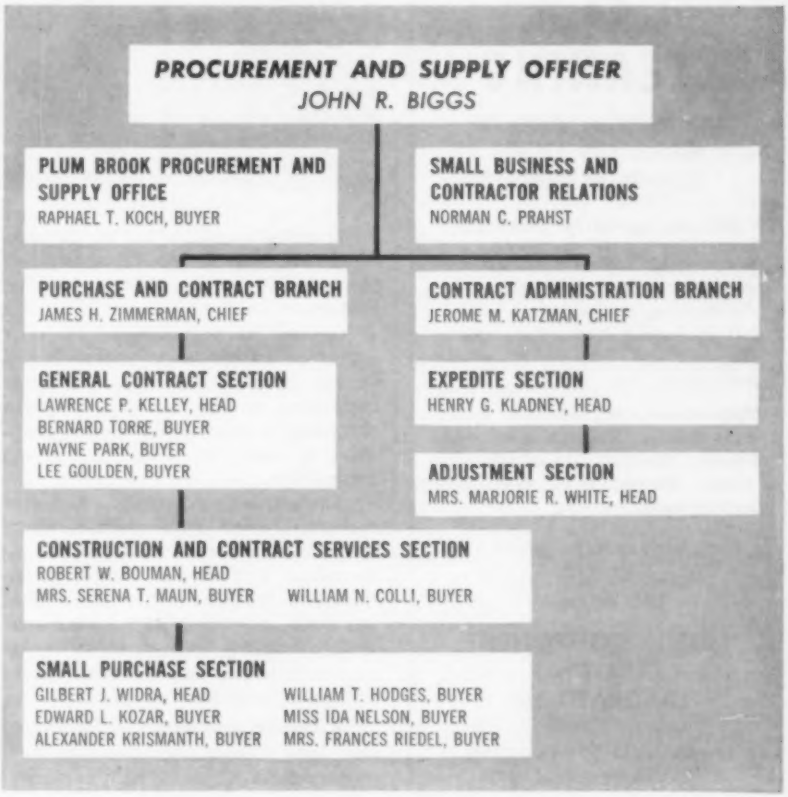
This is not to degrade the industry effort. The division just does not want to learn too much from contractors on a fundamental level.

• **Ion power**—The Electromagnetic Propulsion Division, directed by W. E. Moeckel, is the one section likely to expand because of the shift of all NASA electrical propulsion efforts to Lewis.

The division is currently broken into three branches—electrostatic propulsion, plasma physics and electromagnetics.

The Electrostatic branch is involved in cesium tungsten engines, studies of contact ionization, colloidal particles and the mechanics of propellant feed systems.

The branch is currently building a flight model of the Kaufmann ion engine (named after the Lewis developer) for flight testing with the Hughes engine. The unit operates through the electron bombardment of mercury and



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The Plasma Physics branch studies heating and accelerating plasmas using a traveling wave 40kw power supply and a coaxial transient plasma accelerator. The temperature work is mainly concerned with getting a plasma in a contained magnetic field as hot as possible. If temperatures in the 100,000° to 200,000°F range can be reached, there may be applications in a thermal plasma jet. There is is also some thought of applying thermonuclear power to rocket propulsion.

The Electromagnetics branch is concerned with the development of intense magnetic fields, upwards of 100,000 gauss, for plasma containment and power conversion.

A water-cooled magnet is currently running at 100,000 gauss, and investigations of superconductive materials for radiation shielding are in progress.

Two vacuum chambers and a housing facility are under construction. The chambers—25 ft. diameter by 70 ft. in length, and 15 ft. diameter by 60 ft. in length—will be used for engine evaluation in simulated space environments including both solar radiation and temperature controls. Plans for a large liquid helium facility have been made with the cryogenic supply also slated for some superconductivity work on the big magnet.

Current contracts under the auspices of Marshall are being shifted to this Lewis division.

The Materials and Structures Division, S. S. Manson, chief, is primarily concerned with metals and their behavior under the various conditions imposed by space and space vehicle requirements.

Most of the work is research and fundamental in nature, but the division has handled some specific application projects for Lewis, NASA and the military.

General work in fatigue, effect of imperfections and single crystals in the various metals, alloys and inorganic composites is pursued. The division pioneered in defining the needed properties in steel for aircraft and space applications.

The division's extensive facilities are a research effort in themselves. High-temperature physical measurement instruments, a 1000-ton vertical extrusion press, heating and melting facilities including an electron beam furnace and an arc melting unit currently being modified with a large vacuum work-area (see NASA Materials, p. 68).

• **Plasma parameters**—The Instrument and Computing Research Division, under J. H. Hall, handles fundamental measuring problems as well as providing computer service groups to the rest of the research effort at Lewis.

Fundamental work includes such studies as how to measure the characteristic parameters of ionized beams in plasma, and temperature measuring techniques beyond the current state of the art. Techniques to determine the nature of residual matter in vacuum chambers and the establishment of standard calibrations in liquid hydrogen flow meters are other examples.

The division has two large computers—an IBM 704 and a modified Univac 1103. The latter is part of a built-in data system with direct connections to test cells.

Hall's group also provides onboard instrumentation for certain experimental space shots. The division does not handle all of the Center's instrument work; there are operational groups within each of the other sections.

The Nuclear Reactor Division, under L. V. Humble, is involved in reactor physics and the improvement of reactor theory in general. This division is currently associated with the Plum Brook reactor, but the latter is slated for separate operational status. This will not dissolve the close ties between the groups.

NRD boasts one of the six cyclotrons in the U.S. It is used to investigate the effects of radiation on matter, the determination of half-life in certain materials, and for other purposes.

Humble's group looks at concepts and farms out some problems to other Lewis divisions. Heat transfer problems in reactor technology are also part of the division's effort.

Advanced ideas—such as applying gaseous reactors to nuclear rocket systems—are being studied. Here a typical problem would be how to keep the hydrogen propellant from mixing with the uranium particles. The vortex approach is under investigation. The main reason is to push the nuclear rocket engine temperature higher and higher.

There is also some small effort in the area of the mechanical properties of solid hydrogen. This fell to the division more or less by default, since the necessary equipment was there. Other minor studies are in the properties of hydrogen at 100,000°F.

The reactor division is primarily research, while Plum Brook is more of an operating group. The reactor itself, designed completely by NRD personnel, went into operation last April. The unit is being used as a tool for the study of components and materials under radiation conditions very similar to those anticipated in full-scale, nuclear-powered spacecraft systems. ■

Life Support Effort Upped At Ames

Simulators for advanced spacecraft and major expansion in life sciences spark new growth at West Coast center; most procurement supports in-house programs

NASA'S Ames Research Center at Moffett Field, Calif., is moving heavily into studies applicable to support of manned space flight. This represents a major shift from its long-term function in advanced aerodynamics.

The center's share of NASA's FY '62 outlay has been upped to $30 million, with long-range forecasts of an additional 25% increase within the next 8 to 10 years.

The major programs to be carried on at Ames include:

—Development of multi-purpose advanced space vehicle motion simulators applicable to *Apollo*-type spacecraft and supersonic transport studies.

—Development of life-support systems for extended simulator runs.

—Vibration simulators to aid in the study of *Saturn* launch vibratory characteristics.

—Life sciences, slated for a major expansion with probable breakdown into exobiology, environmental biology, biotechnology, and physiological and behavioral sciences.

—Guidance, control, and re-entry studies with applications to *Apollo*, *Dyna-Soar*, and other manned spacecraft.

Exactly what this build-up in the simulator and life science areas will mean in terms of actual physical equipment and expansion is difficult to predict with any accuracy at this point. Ames has a considerable in-house capability for fabricating its own devices, usually at heavy savings.

For example, the center's recently completed centrifuge and cab device was put together using much existing hardware for $385,000. Center engineers estimate the cost would have been $4 million had external production been necessary. Special analog devices and electrical power requirements also lend themselves to in-house development by Ames since few, if any, of these items are commercially available.

SMITH J. DeFRANCE
Primates and personnel—a problem

• **Low procurement**—Ames is among NASA's smallest installations in the amount of money spent with industry. Most of its outside buying is in purchase orders, not contract awards, since it is not a production facility.

Ames was involved in only 2% of the total NASA procurement (items over $25,000) in FY '61. This does not include utility contracts—electric power alone costs the center some $2 million per year. Excluding utilities, Ames spent about $11 million last year and will probably exceed this for FY '62. One of the center's major outside contracts at present is a Mach-50 test facility. Total for this high-speed, high-temperature unit may be $5 million.

Electronics and electrical devices comprise the largest share of all Ames procurement (no percentage figure is available). Most of these purchases involve components rather than complete assemblies or systems.

Approximately 22% of the center's procurement dollar volume goes to small business. This also translates as 71% of the center's procurement actions.

Some procurement and contract awards are difficult to categorize—the center both buys and leases its computing equipment. Also, construction costs, which have been between $7 and $15 million per year, are not always reflected in the center's budget because the appropriated funds may not be awarded within a specific fiscal period.

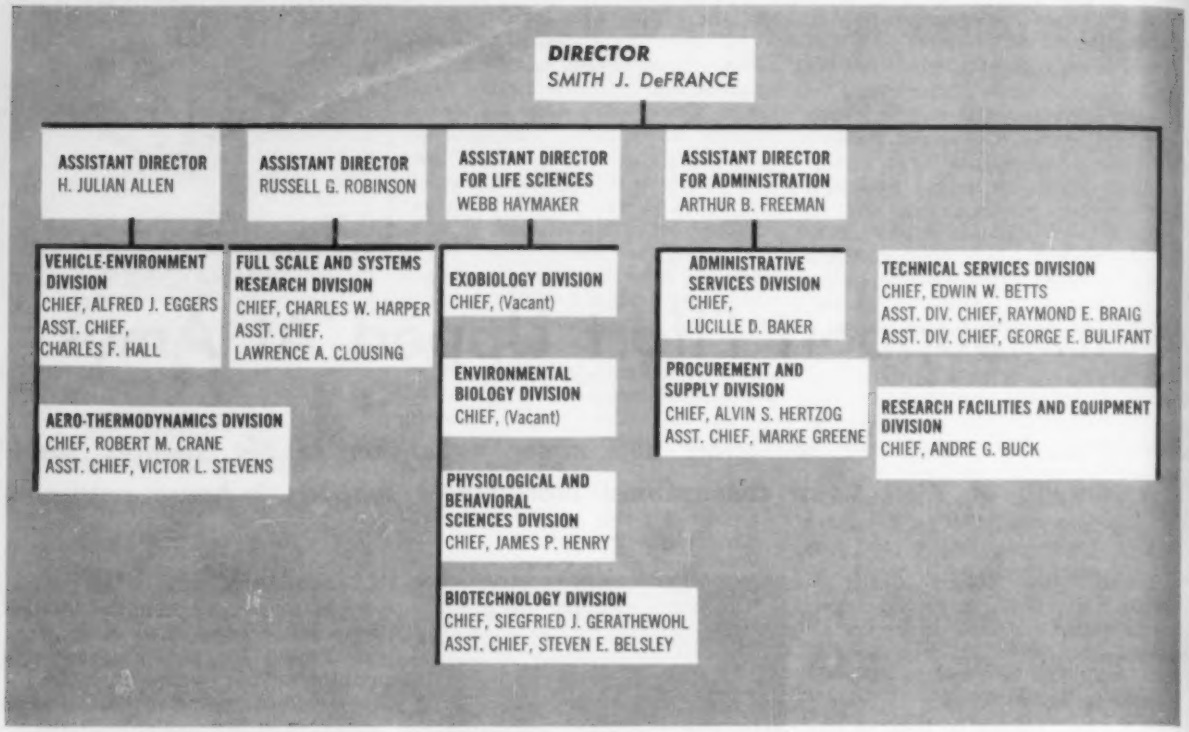
• **Costs up** — Operating costs at Ames have jumped in the past two years by about $1 million and are running currently between $4 and $5 million annually. For example, about 12 million cubic feet of helium are used per year and the price is rising.

There is also a trend at Ames towards the use of consultants on certain projects, such as the construction and fitting-out of the center's new radioisotope laboratory.

Another factor affecting both procurement and facilities at the center is the buildup of personnel—particularly in professional fields. NASA plans call for 162 new persons to augment the staff at Ames by June 30, 1962. This will bring the total to 1675.

Plans to develop primate training facilities at Ames illustrates the personnel problem—if it is a problem. There are two accepted and proven systems for primate training that may be purchased with relative ease.

The system which Ames intends to



use, however, is a combination of two selected at the suggestion of scientists involved with the project-to-be. They believe that the combination system will do a better job than either of the other two, but it poses some problems with contractors in trying to purchase portions of complete systems.

In the space simulator area, it is difficult to pin down Ames' efforts on programs such as *Apollo*. However, a group has been formed which will work directly in simulation for various *Apollo* phases after the program has been better defined.

Some type of environmental adaptation to the present simulators will probably be needed, and may go out to industry in contracts. A life support system for extended simulator runs will be high on the list. This can be purchased on a reasonable off-the-shelf basis. Ames scientists feel there is at least one and probably more such systems that would meet their requirements.

In other areas, such as air conditioning for the simulators which would duplicate space conditions, the center believes it may be able to purchase systems. Some of these are not yet on the market, but Ames is aware of some systems built by various firms hoping for *Apollo* usage.

Vibration simulators are another area of interest, but Ames says it will have to have far more data on *Saturn* launch vibration characteristics before it will decide exactly what it needs.

• **No duplication**—The life sciences group is beginning a slow expansion. It has been authorized 100 persons this fiscal year, but the type of personnel this group seeks is not easy to find. The 100-person figure does not include support personnel.

Now in the process of forming into organized groups, the division will probably break down into four major areas mentioned earlier. The bio-technology group will apply its efforts in direct support of human factors for manned space programs.

The center says that the life sciences group will not duplicate work being done by the Air Force or other groups —much of the work they plan has not been an AF function to date. Most current work in areas under consideration by the life sciences group is being conducted by universities. About 50% of the university effort has been on the West Coast. Ames plans to keep some of the work in universities on a contract basis if the universities demonstrate competence.

• **G&C work**—Other major efforts which tie directly to *Apollo, Dyna-Soar,* and other manned space vehicles involve guidance and control studies, and re-entry techniques.

Ames has about 35 scientists and engineers working directly on support of *Apollo* guidance (both mid-course and terminal) and control systems. This group has been working together for about two months, but some portions of their work (abort guidance and mid-course technique) have been underway for about five months. The center's effort in guidance and control for *Apollo* is basically a backup of MIT programs, plus analysis and evaluation.

Apollo guidance is between 50% and 60% of the center's total guidance work. The program will probably double the amount of professional personnel within the next year to 18 months.

Other guidance and control work at Ames includes satellite stabilization systems and human factors.

Re-entry study is another active area at the center—an estimated 20% of the center staff is directly engaged in re-entry studies (the blunt nose cone concept was developed at Ames with first proof successes in June, 1952).

Most of its *Apollo* work grew out of the satellite re-entry studies. Industry has worked very closely with Ames in the development of *Apollo* configurations. Only two companies involved in initial *Apollo* competition have not used Ames-developed data.

One of the most important groups at Ames supplying a big boost in versatility is the instrumentation division. Comprised of about 250 people, the unit has between 75 and 80 professionals in such areas as electrical and electronic engineering, mechanical engineering, physicists, chemists, mathematicians, physical chemists and an astronomer. Some devices developed by the instrumentation division have been picked up by industry and are now available on a commercial basis. ■

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Spacecraft Recovery Role for Edwards

PAUL F. BIKLE
For FRC, a period of major growth

X-15 remains primary project at Flight Research Center but officials expect FY '63 budget to double if step-up occurs in perfecting landing system for Apollo vehicle

NASA'S FLIGHT Research Center at Edwards AFB, Calif., is one to watch in the area of space operations support.

Right now FRC officials are predicting their FY '63 budget will hit $13.6 million—double the $6,588,000 being spent in the current fiscal year—and spending may go as high as $20 million in 1970.

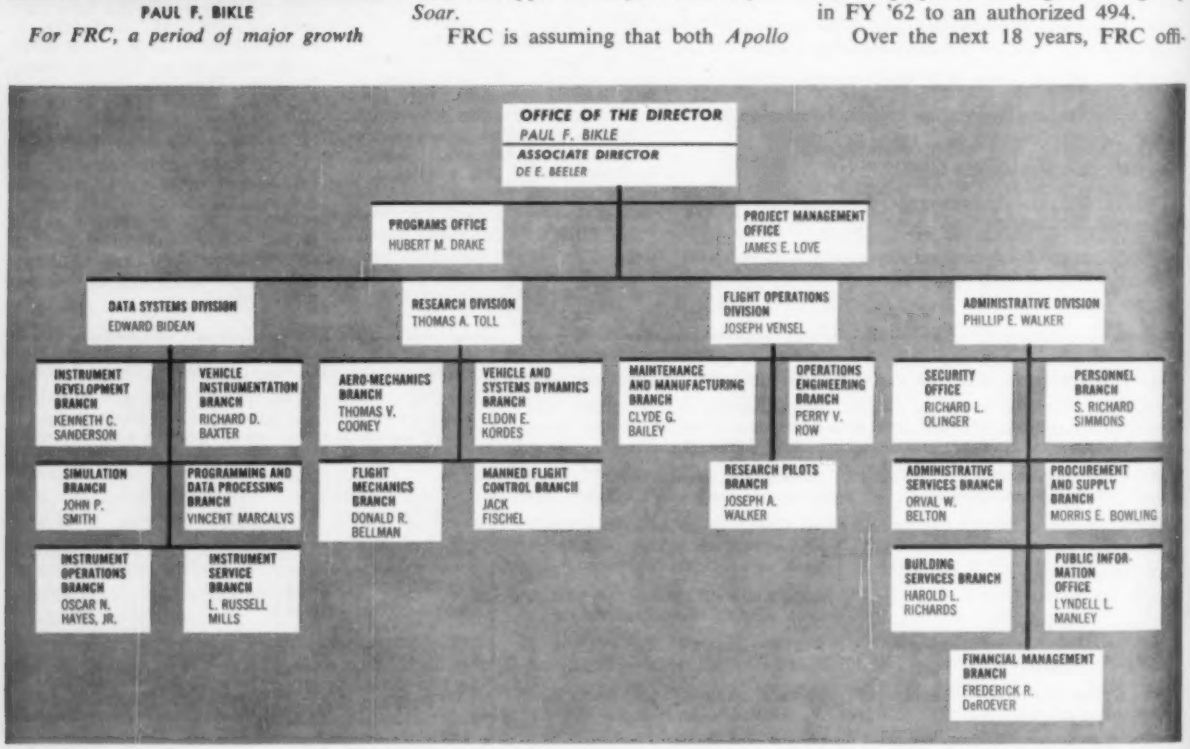
This forecast appears partly dependent upon just how major a role the center is given in the development of booster and space vehicle recovery systems in support of *Apollo* and *Dyna-Soar*.

FRC is assuming that both *Apollo* and *Dyna-Soar* will be recovered in the vast desert areas surrounding Edwards. But no decision has been firmed up yet, either by NASA or the Air Force.

In any event, FRC is embarking shortly on an extensive program in the evaluation of the Rogallo wing, which may be used in the recovery of big boosters and possibly spacecraft.

• **In-house oriented** — Like Ames Research Center, the Edwards facility is mainly oriented in-house. It is rather small compared to other centers, having 419 employees. This figure will go up in FY '62 to an authorized 494.

Over the next 18 years, FRC offi-



cials hope to broaden the center's abilities. They see their efforts moving in the following directions:

Fields	% of Effort 1962	1965	1970
Propulsion—Environment	5	7	7
Fluid Mechanics	10	9	2
Operating Problems	5	5	5
Recovery Systems	—	12	19
Materials, Loads, Structures	20	14	14
Aerodynamics	25	20	15
Orbital Rendezvous	—	8	8
Control and Guidance	35	25	30

The primary program at FRC is still the *X-15*. The program is now at peak level and will probably stay that way for another year in support of additional research programs.

FRC officials say there is a "very wide field" open with the *X-15* aircraft in experiments involving high-temperature, high-mach number flight regimes. There are a tremendous amount of *X-15* inputs and proposals from many sources. When they are all milked down, the *X-15* becomes the only vehicle available for them. But as presently scheduled, the *X-15* will be phased out in about 18 months.

"We have only scratched the surface of *X-15* possibilities and intend to maintain about the same amount of work with the aircraft well into 1963," a FRC official says.

• **Dyna-Soar switch** — The center already has a major effort going on *Dyna-Soar*. Three NASA pilots are assigned to Boeing for the project, and at least one of the three is at Boeing at all times.

For *Dyna-Soar*, FRC will step out of the familiar operational phase it has held in programs such as the *X-15* and move into technical support.

FRC is also developing some *Dyna-Soar* hardware specifications to assure that maximum benefit will be obtained from the test program. The center's approach to this area is much the same as it was for development of *X-15* technical data. When this phase of *Dyna-Soar* is completed by FRC, it will spend a good deal of time planning for overall *Dyna-Soar* operations.

In another area of *Dyna-Soar*, FRC will play a large part in developing instrumentation specifications to get needed data and research information. It will also have the responsibility for reduction and publication of *Dyna-Soar* data. But, FRC project directors point out, the center will only be involved in technical aspects—the Air Force will handle all *Dyna-Soar* operational areas.

If *Dyna-Soar* and *Apollo* are recovered at Edwards AFB, a buildup of FRC's recovery and tracking capabilities would be needed. But the center says this would not be a major project as far as installation of a large amount of additional equipment is concerned. Much of what would be needed for both projects is already at hand and in use for the *X-15* program. Some equipment modifications would be in order, but FRC already has the capability to guide a manned vehicle recovery.

FRC is developing some instrumentation requirements for *Apollo* recovery and has been working on lunar landing studies.

The center is studying rendezvous techniques using a manned system, and has built a small development model of such a system. Still other work includes some studies of non-winged lifting bodies.

• **Aircraft work**—A very large portion of FRC work will be on the supersonic transport. The center is slated to receive its first B-58 next spring for operational and SST handling studies.

There is a considerable amount of cross-over between the work at FRC and at Ames. Some of the same areas are being studied but from different points of view. Ames is concerned with large amounts of research. FRC is concerned more with development aspects.

FRC facilities include the basic 170-acre "corner" at Edwards AFB. It has a large laboratory area, two hangars, supporting shops and shop equipment.

There are four fixed-base simulators, but no motion simulators at the present time. In the future, a general purpose flight simulator, a high-temperature loads calibration facility and other additional buildings are planned.

The center looks upon its aircraft as simulators. Going back upstream in the *X-15* program, FRC's variable stability F-100 and reaction control-equipped F-104 have both made major contributions to the *X-15* as well as other programs. The *X-15* itself can well be considered a simulator for still more advanced hardware and flight techniques.

Most of FRC's budget goes for its own operations. Its procurement runs mostly to relatively small purchases. It prefers to operate similar to Ames—buy the parts it needs, but put together its own systems to meet its own specific requirements. ⌗

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- today's ultimate in microelectronics—with the highest function/size ratio for your digital circuits or equipments.
- provide reduced microelectronic cost through TI's standard silicon wafer design.
- meet military requirements:

Power Drain	2-4 mw @ 3 volts
Fan-Out (TI SN 510, 512, 514, 515)	4
Fan-Out (TI SN 511, 513)	20
Propagation Delay	75 to 450 nsec
Power Supply	3 to 6 volts
Temperature Range	−55° to +125°C

UNIT	TI SN 510	TI SN 511	TI SN 512	TI SN 513	TI SN 514	TI SN 515
FUNCTION	Flip Flop, Counter	Flip Flop with emitter follower output	NOR/NAND Gate (6 input)	NOR/NAND Gate (6 input) with emitter follower output	Two NOR/NAND Gates (3 inputs each)	Exclusive OR
	Clock pulse is internally capacitive-coupled					

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NEW BFG SOLID PROPELLANT PACKS MORE PUNCH OVER EXTREME TEMPERATURE RANGE

A new series of high-density propellant compounds, called Nitro-C rubber, provide 6% more energy per pound than present rubber-based fuels. This increased output permits reduction in weight and physical size of small rocket motors. The propellant retains its physical properties over an extreme temperature range . . . from −110°F to +250°F . . . and is vastly superior to other high-energy composites at both temperature extremes. This makes the propellant dependable for tactical military missiles, as well as for high-mass-ratio motors for space probe and satellite applications. The B.F.Goodrich Rialto Plant, which developed the Nitro-C compounds, is equipped to handle complete small rocket motor projects . . . from research through design, testing and production. For complete information write *B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Akron, Ohio.*

B.F.Goodrich aerospace and defense products

Raytheon brings proven guidance and se

Three techniques are currently available to meet the challenge of Space Rendezvous Guidance: radar, infra-red and optics. Of these techniques, radar has been used for homing guidance systems to the greatest degree. Studies by Raytheon, whose radar experience spans three decades, have indicated that continuous wave radar possesses these desirable characteristics:

- No minimum or 'blind' ranges
- Greater range for a given weight
- Simple FM Techniques for ranging
- Direct and accurate velocity readings
- Ease of acquisition
- Greater simplicity and reliability

sensor capability to space rendezvous

The experience gained from the inertial guidance system for the advanced Polaris, coupled with the proven success of the Hawk and Sparrow C W homing systems give Raytheon the most extensive proven capability applicable to the space rendezvous guidance problem.

In addition, Raytheon, one of the world's largest scientific-industrial organizations, has proven its ability to manage every phase of a complex system — from early study and design through development, production and field support of operational systems and equipment.

Missile and Space Division, Bedford, Massachusetts

RAYTHEON COMPANY

MISSILE AND SPACE DIVISION

RAYTHEON

Circle No. 93 on Subscriber Service Card

STL has moved to its Space Technology Center, built on a 110-acre site at Space Park, Redondo Beach, California. This new industrial complex is designed specifically for research, development, fabrication, integration and test of spacecraft, subsystems, components and ground support equipment for manned and unmanned space missions. A major feature is the high-bay manufacturing building which provides complete facilities for the manufacture of electronic, mechanical and structural hardware, and for sophisticated environmental testing employing a broad spectrum of simulated conditions affecting the launch and performance of spacecraft. In the thirty-foot diameter space simulation chamber, rigidly controlled simulation of solar heating, space vacuum and vehicle heat radiation to outer space permits acquisition of data to give maximum assurance of quality and reliability. Available for current and future STL programs, the augmented manufacturing facilities at Space Technology Center will soon be producing standardized Orbiting Geophysical Observatory satellites for NASA, in the tradition of technical excellence and performance typified by Pioneer V.

SPACE TECHNOLOGY LABORATORIES, INC.
a subsidiary of Thompson Ramo Wooldridge Inc.
One Space Park, Redondo Beach, California

Technical Countdown

ASTRONAUTICS

Micrometeoroid Studies Pushed

Particle velocities of 20,000 ft./sec. are being achieved by Technical Operation Inc., of Burlington, Mass., in its studies of micrometeoroid collisions with space vehicles. Using a "gun" based on the exploding bridgewire principle, micro-size particles are accelerated and impacted against samples of various metal now in use in spacecraft hull construction. Work is sponsored by Aeronautical Systems Div. of AFSC. Test results will aid in determining "probable effects". However, past space flight research has indicated that micrometeoroids in infinite numbers traveling in showers may attain velocities up to 250,000 ft./sec.

Advanced Control System Developed

Rotatable auxiliary rockets are used in a new missile/space vehicle control system developed by Allison Division of General Motors. Designed for altitude and velocity control, it provides highest payload yet of any thrust-vector system, developers say. Described as highly efficient and compact, the control system can operate fore and aft of main propulsion motors to assist in staying, velocity trim, and coast.

PROPULSION

X-15 Headed for New Heights

Having carted away all the speed records in sight, NASA's *X-15* experimental rocket plane is literally looking around for new horizons to conquer. Around the middle of next year, according to one Edwards AFB source, the *X-15* will be flown at much higher altitudes—around the 400,000 ft. mark. The plane now holds the unofficial altitude record of 217,000 ft. for manned, powered flight. Main point of controversy in the high-altitude flight program is whether the existing powerplant can do the job. As yet, this question has not been resolved.

SUPPORT EQUIPMENT

New Facilities for Goddard

Goddard is planning to install a series of "exotic" facilities to check out satellite payloads. In the works are a magnetic test facility able to produce rotating and controllable and magnetic fields, a moment-of-inertia facility for testing spacecraft control systems, and—still a few years off—a 100 ft. centrifuge for work with *OGO* and *POGO* satellites. These facilities are in addition to two environmental chambers the Center has under construction.

Thiokol Diversifies Into Ground Vehicles

A lightweight, low-cost tracked vehicle produced by Thiokol's Logan works is under review by the Army. The unit, capable of climbing 45°-plus slopes and traveling over mud, snow, sand and rocks, has already been accepted by the Air Force. Commercial applications are also under investigation.

SPACE MEDICINE

Martian Microorganisms a Menace?

Space-vehicle sterilization is a two-way street. Human survival on earth could depend on avoidance of contamination from returning vehicles, Lockheed Missile & Space Co. scientists assert. The group has proposed a five-year program to study biological decontamination techniques and to build ground and in-flight sterilization units before round-trip space missions are effected.

ADVANCED MATERIALS

Cermet Coatings Protect to 2500°F

AMF scientists have protected molybdenum against oxidation for five hours at a temperature of 2500°F with an electrodeposited layer of an Ni-Si cermet 5 mils thick. In parallel tests a Ni-Zr oxide cermet, also 5 mils thick, stood up on molybdenum for 468 hours at 2000°F. These and other systems were prepared by co-depositing the particles with the metal in the baths.

Tungsten Nozzle Liners in Production

Rocket nozzle liners and jet vanes of high-pressure cast tungsten alloy are in production at Oregon Metallurgical Corp. The material is directly forgeable without prior breakdown, due to the fine grain structure. The casting is made by pouring arc-melted molten metal into rotating graphite molds.

Three-Story Electron Beam Furnace

Temescal Metallurgical Corp. has turned out a tantalum-tungsten ingot 7 in. across and 6 ft. tall. The ingot was formed in a three-story electron beam furnace capable of more than a million pounds per year of exotic metals. The ingot size will make possible economical production of larger missile parts. The 90Ta-10W alloy can take temperatures ranging from −420° to 6500°F.

Non-polymeric Polymers Through Radiation

The National Bureau of Standards has succeeded in polymerizing such normally non-polymeric monomers as carbon disulfide by initiating the reaction with radiation and favoring it with pressure. While the work has not progressed far enough to warrant detailed conclusions, some general theories have been formulated on the pressure effects and reaction parameters.

Navy JATO's at McGregor

Rocketdyne will be producing MK-25 JATO's under a BuWeps contract at the firm's McGregor facility in Texas. The units provide 4500 lbs. thrust for five seconds and contain a flameless propellant. The exhaust gases will not produce fogging conditions which might hamper takeoff operations.

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FLUIDS TO HELP TAME FIRE HAZARDS

Fire-safe hydraulic lifts, loaders, and launchers!

A hydraulic oil leak sprayed from an underground service elevator can ignite on contact with a welding torch, an arcing circuit breaker, even a broken light bulb. Chance ignition of a flammable fluid in a missile launcher, mobile lift, or weapon loader could cause disaster, destroying both missile and base. Monsanto can supply a whole series of fire-resistant *all-synthetic* hydraulic fluids that operate reliably over a wide temperature range. They will not corrode metals; will not clog pumps or valves; will resist change in composition or physical properties even after *years* of storage and service. For maximum fire protection of below-ground military installations, put Monsanto fluids specialists to work—checking out ignition dangers with *your* "hard" base hydraulic equipment designs.

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2. Years-ahead research on new types of fluids
3. Time-saving facilities for testing new uses
4. More *job-proven* functional fluids than any other manufacturer in the world
5. Design-oriented *know-how* to help you develop more compact, safer, and more reliable equipment

TYPICAL PROPERTIES OF A FEW MONSANTO FLUIDS	OPERATING TEMPERATURE RANGE (°F)	VISCOSITY (centistokes @ °F)	POUR POINT (°F)	MAXIMUM LONG TERM BULK TEMPERATURE (°F)	SPECIFIC GRAVITY 25°/25°C
SKYDROL® 7000	−40 to 200	15.5 @ 100 4.00 @ 210	<−70	200	1.08
SKYDROL 500A	−65 to 225	2300 @ −65 11.5 @ 100 3.92 @ 210	<−85	225	1.07
PYDRAUL® 60	−25 to 200	10.0 @ 100 2.45 @ 210	−70	200	1.09
PYDRAUL 150	−15 to 200	30.8 @ 100 8.0 @ 210	−55	200	1.13
PYDRAUL F-9	+50 to 300	47 @ 100 5.5 @ 210	0	300	1.28
PYDRAUL A-200	+50 to 300	31 @ 100 2.86 @ 210	+10	300	1.42
PYDRAUL AC	+60 to 300	88.2 @ 100 5.15 @ 210	+20	300	1.35
OS-81	+50 to 300	34.0 @ 100 3.1 @ 210	+20	300	1.40

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Fire-safe electrical generation and distribution!

If you are designing, installing, or operating electrical power systems for below-ground service, let Monsanto guide you to greater fire safety for these vital installations. Oil *under ground*, in bulk storage or in service, can be hazardous—far more critical than above ground. Monsanto fluids assure greater safety—with *fire-resistant turbine lubricants, fire-resistant dielectric fluids* for *high confidence level* transformers in substation distribution points.

Transformers filled with Monsanto fire-resistant askarels have been used for years by major utility companies to assure safe, reliable performance of their equipment. Build maximum fire safety into your ground support equipment with Monsanto fluids that eliminate fire hazards.

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328,000	28.9	0.00042	YES	Commercially Available	YES
308,000	30.8	0.00045	YES	"	YES
328,000	—	0.0004	YES	"	YES
319,000	—	0.00042	YES	"	YES
387,000	—	0.00041	YES	"	YES
400,000	—	0.0004	YES	"	YES
375,000	—	0.0004	YES	"	YES
—	—	—	YES	Development Product	YES

ASSURE RELIABILITY AND SAFETY

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You're looking at a tape-programmed jig borer at the Sperry Farragut plant in Bristol, Tennessee.

Part of one of the country's largest such machine tool installations, its output is devoted exclusively to the economical production of precision mechanical and electromechanical components . . . reliable components of intricate control systems that guide many of the nation's successful missile and satellite "shots" and that will guide SATURN space explorations.

Advanced machine tools of this type are typical of Sperry Farragut's modern production facilities, which include one of the most extensive and up-to-date "clean room" areas for precision assembly work, and comprehensive equipment for product environmental evaluation.

At Sperry Farragut, full realization of equipment potentialities is assured by a highly trained staff with wide experience in guidance system production —skilled personnel motivated by a sense of urgency and dedicated to achieving the highest quality and reliability attainable.

Contracting agencies and government contractors are invited to talk over application of Sperry Farragut facilities and capabilities to their specific projects. Our liaison engineers will welcome an opportunity to discuss your requirements. O-3

Capabilities and facilities for study, design, evaluation, prototype construction, and final quantity production of precision systems, subsystems, and components for:

- *Missile guidance and control*
- *Fire control*
- *Aircraft instrumentation*
- *Navigation—land, air and sea*
- *Computers*
- *Trail marking equipment*

SPERRY FARRAGUT COMPANY

DIVISION OF SPERRY RAND CORPORATION

BRISTOL, TENNESSEE

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ENGINEERS ARE CHARTING A NEW COURSE AT AC

AC's newest assignment is Systems Integrator for the modified B-52C&D Bombing Navigation System. AC's responsibility includes program and engineering integration, and coordination of associate contractors in the production phase. ■ Other programs at AC include a new, miniaturized inertial guidance system for the TITAN II missile. In addition, AC's Los Angeles Advanced Development Laboratory is currently developing Advanced INertial Guidance Systems. ■ AC is seeking qualified men to work on these important projects. If you have a BS, MS or PhD in Electrical Engineering, Mechanical Engineering or Physics, please contact Mr. G. F. Raasch, Director of Scientific and Professional Employment, Dept. 5753, 7929 South Howell, Milwaukee 1, Wisconsin. An Equal Opportunity Employer. ■ Immediate positions available:

Milwaukee

Radar Systems Engineers • Radar Test Engineers
Radar Reliability Engineers • Design Review Engineers
Contact Engineers • Field Service Engineers

Los Angeles

(Advanced Inertial Guidance Systems—Airborne Computers)
Transistor Circuit Design Engineers
Sr. Digital Computer Development Engineers

■ AChiever Inertial Guidance Systems for TITAN II, THOR and MACE—Bombing Navigation Systems for the B-52C&D and B-47—AChieverfone mobile radiotelephones.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

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Pulse Modulated Rocket

A significant advance in space vehicle control devices may accrue from development of a pulse-modulated bipropellant control rocket at Vickers Inc. The control rocket incorporates a solenoid, bipropellant valves, and thrust chamber in one compact unit, to insure reliability, fast response, efficiency, and low power input. It uses a bipropellant combination of N_2O_4 and N_2H_4/UDMH. The control rocket shown was developed for vernier attitude corrections of space vehicles with a pulse modulated thrust level of 1 lb. The unique design results in an overall response time in milliseconds, excellent repeatability of impulse bits, and power input requirements of only a few watts.

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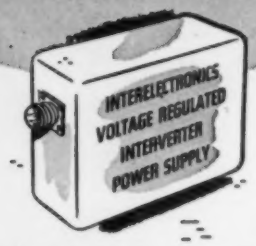
PROVEN RELIABILITY—
SOLID-STATE POWER INVERTERS
over 260,000 logged hours— voltage-regulated, frequency-controlled, for missile, telemeter, ground-support, 135°C all-silicon units available now—



Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. Wide input range (18 to 32 volts DC), high conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry).

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards).

Complies with MIL specs. for shock (100G 11 msec.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how —has designed and delivered more working KVA than any other firm!

For complete engineering data, write Interelectronics today, or call LUdlow 4-6200 in New York.

INTERELECTRONICS CORPORATION
2432 Grand Concourse, New York 58, N. Y.

Circle No. 28 on Subscriber Service Card

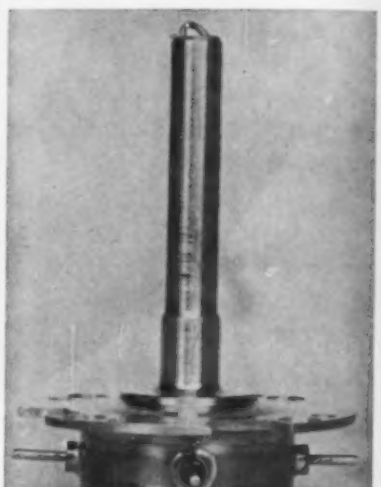
Pyrotechnic Initiators

Pyrotechnic initiators with electronic circuitry are in production by Fleming Industries, Inc. Designated Model IN-113, the heavy-duty electronic unit contains a low brisance squib which will not fire with 250 VAC RMS applied continually but will always fire at 500 VAC RMS (700 VDC) or more. The squib has a controlled burning rate for igniting secondary charges without detonation. The initiator is completely shielded and filtered for protection against RF and other radiation.

Circle No. 226 on Subscriber Service Card

Vertical Sensing Element

Kearfott Division, General Precision, Inc. has available the 218995-1 electromagnetic vertical sensing element. This gravity-sensitive, liquid, damped pendulum device can be applied to any vertical sensing situation requiring an



electrical output. A jewel-suspended permeable mass acts as the variable reluctance portion of two orthogonally mounted differential transformers to provide a phase-sensitive output signal proportional to tilt angle.

Circle No. 227 on Subscriber Service Card

Magnetic Measurement

A light-spot ballistic fluxmeter that can be used for flux and strayflux measurements on permanent magnets, d-c electromagnets and solenoids of all kinds is available from Halltest Division, Instrument Systems Corp. The

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Circle No. 95 on Subscriber Service Card

instrument is also capable of short-time impulse measurements from 0.1 millisecond up to 1 second. Other specifications include ranges of 500-1000-2000 - 5000 - 10,000 - 20,000 - 50,000-100,000-200,000-500,000 Maxwell turns/division. Internal resistance is 40 ohms, approx., in lowest range. Load resistance (test coil) is 0-60 ohms in lowest range and 30 ohms in other ranges. Absolute accuracy is + 1%, relative accuracy is + 0.2 divisions.

Circle No. 228 on Subscriber Service Card

Noise-Free Power Supply

A noise-free family of power supplies, featuring precise voltage regulation for both line and load, is available from Raytheon. The six Sorensen QIS 60-cycle models and the six DQIS 400-cycle models are transistorized, miniature 115-volt AC/DC, sine-wave inverters. Operating from 12 or 28-volt DC inputs, the 12 units' outputs, obtained from a Class B amplifier, are 20, 40, or 60 watts. An ideal replacement for vibrators, the Sorensen supply has eliminated frequency noise and reduced audio noise to a negligible amount. Applications include tape motors, small magnetic amplifiers and gyros, and similar equipment operating indirectly from batteries.

Circle No. 229 on Subscriber Service Card

Low-Weight Antenna Mount

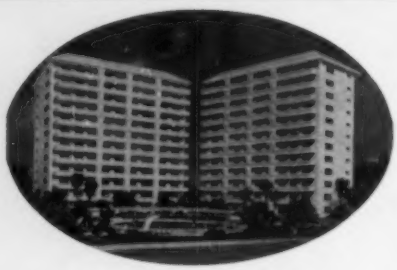
Weighing less than 1000 lbs., antenna mount Model 28, a servo controlled pedestal for shipboard and ground-based application, is available from Temec, Inc. It is designed for use in telemetry reception and the tracking of aircraft missiles and satellites. Special features include gyro stabilization for shipboard use, a complete solid-state

a-c servo system and automatic beam crossover switching from 3db to 9 db. Current production model employs a 5-ft. reflector for use in the 5 kmc. range, but other reflectors and frequencies are available on order. The curernt system has slew rates of 36°/sec., and accelerations of 130°/sec./sec.

Circle No. 230 on Subscriber Service Card

2500 Channel Repeater

Philco Corp. has developed a low-cost coaxial cable communications repeater with bandwith capability of 2500 voice channels. The tubular 6 in. x 1 in. cable repeater weighs only a few ounces. A cable communications system, employing the 2500-channel ca-



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● THE LIONEL CORPORATION, (Now includes **Hathaway Instruments, Inc.**)

• Clemco Aero Products, Inc., Gardena, California • Dale Electronics, Inc., Columbus, Nebraska • Hathaway Instruments Division, Denver, Colorado • Induction Heating Corp., (Ther-Monic®), Brooklyn, New York • Intercontinental Manufacturing Co., Garland, Texas • Lionel Electronic Laboratories, Brooklyn, New York • Lionel-Wadsworth, (Ultrason®), New York • M. Steinthal & Co., New York & Roxboro, North Carolina • Sterling Electric Motors, Inc., Los Angeles, California • Telerad Division, Flemington, New Jersey • Lionel Toy and Train Division (and Lionel/Porter), New York, New York / *The merging of Lionel and Hathaway generates an unusual capability in the fields of electronics, hydraulics, and nucleonics. From components through subsystems to complete military systems projects, Lionel can be counted upon as a proven source with a new corporate competence.*

THE LIONEL CORPORATION
Executive Offices: Hoffman Place, Hillside, New Jersey

pacity repeater, initially costs about the same to install as a typical 240-channel microwave system. Multiplexing equipment would be used at either end of the system, as in a microwave system.

Circle No. 231 on Subscriber Service Card

Drill Speeder

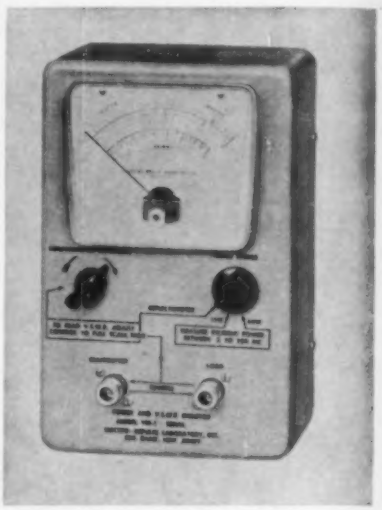
Following the first Drill Speeder Model #62 which increased spindle speeds at a ratio of 7 to 1 with a maximum drilling speed of 22,500 rpm,

Tapmatic Corp. has added the Drill Speeder Model #125 to their line. This unit has a ratio of 6.25 to 1 and a capacity from #80-⅛". The Model #125, permits quick and easy installation on all types of drilling machines. The Tapmatic Drill Speeders can be used in manual, semi or completely automated operations on all types of drilling machines.

Circle No. 232 on Subscriber Service Card

VSWR Power Meter

A feed-thru power meter and VSWR Power Meter, Model VM-2, covering the range of 1 to 30 MC and Model VM-1, covering the range of 10 to 200 MC, is available from Electro Impulse Laboratory, Inc. These RF power meters consist of a voltage divider of

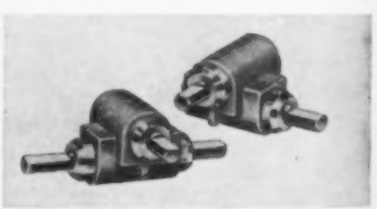


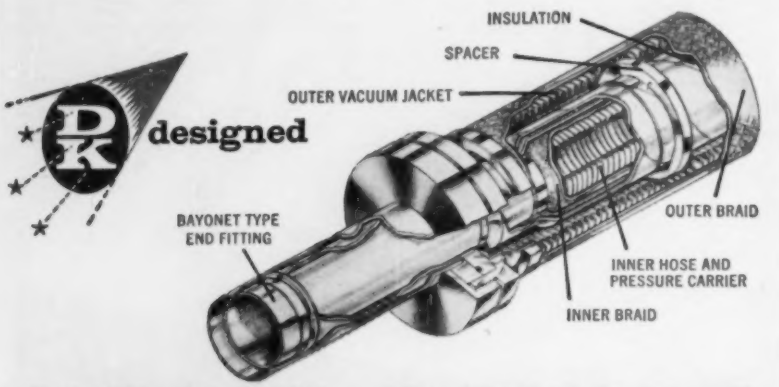
the feed-thru type and a reflectometer. The frequency range of the voltage divider is d-c to the upper frequency limit of the instrument. A crystal diode across a portion of the voltage divider measures the RF voltage which is indicated on a volt meter calibrated in watts. Because of this feature, the voltage divider can be calibrated at power line frequencies.

Circle No. 233 on Subscriber Service Card

Angle Drives

The F. W. Stewart Corp. is marketing two angle drives. The 9056HF (T-drive) and 9056-119 (Right Angle Drive) are provided with ¼ in. diameter shafts out to a 1/16 in. flat to provide a stronger attachment for coupling ends. Primarily used with flexible shafting,





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DK manufactured vacuum jacketed cryogenic lines have exceptionally low heat exchange!

Take a close look at the design and construction of the vacuum jacketed transfer line shown here. You'll quickly see why it answers the problem of transferring costly cryogenic materials most adequately!

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- Certified LOX Cleaning Facilities
- Certified Testing Facilities
- Complete Fabricating Facilities
- Approved Quality Control

DK has combined experience, design capability and advanced manufacturing technique into producing a wide selection of vacuum jacketed transfer lines constructed of flexible metal tubing, rigid tubing and vacuum jacketed gimbals in many combinations. These cryogenic lines are finding diverse applications in Airborne as well as G.S.E. service. Available in standard sizes or in special designs to meet special needs.

Our new brochure has complete information including test data. Write, wire or phone for a copy today. Ask about "vacuum jacketed cryogenic transfer lines."

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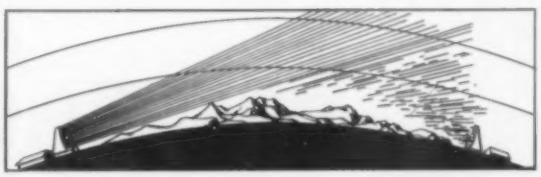
ALERT: Litton Communication Systems Advance the Defense Posture of the Free World

Management of electronic communication systems is a proven capability of Litton Industries, whose European facilities alone include 750,000 square feet under roof and a 3600-man team of engineering, manufacturing and field support specialists.

Professionals qualified to contribute to or direct research, engineering, production or field service in communications and allied fields are invited to investigate the broad spectrum of career opportunities at Litton. An equal opportunity employer.



LITTON SYSTEMS, INC.
BEVERLY HILLS, CALIFORNIA
A DIVISION OF LITTON INDUSTRIES

TECHNOLOGIES: ADVANCED COMMUNICATION AND DATA RECORDING • COMMAND AND CONTROL • GUIDANCE AND CONTROL • COMPUTERS • BIOELECTRONICS • SPACE SCIENCE • ELECTRONIC COUNTERMEASURES

Department Head—Aerothermodynamics

This new position is currently available in our Engineering Sciences activity. We are seeking an outstanding scientist who has the stature and maturity to provide technical leadership for a small group of highly qualified aerothermo specialists performing studies concerned with advanced rocket propulsion systems.

The position requires a high degree of creativity. Selected candidates will possess a record of major responsibility and accomplishment in this field, and will be thoroughly knowledgeable in analysis and test work. An advanced degree, preferably a doctorate, in mechanical or aeronautical engineering with a minimum of five years experience is required.

This is a stimulating, challenging position with recognized professional leaders at UTC's modern multi-million-dollar complex, where the very latest techniques, methods, ideas and equipment are available. UTC is located in the San Francisco Bay Area, which features "West Coast living" at its finest.

If you are interested, we invite you to contact C. F. Gieseler, Dept. 109, United Technology Corporation, Box 358, Sunnyvale, California. All replies treated in strictest confidence.

All qualified applicants considered without regard to race, creed, color or national origin.

UTC

United Technology Corporation

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...products and processes

these adapters allow for a variety of uses far wider than being used in conjunction with flexible shafting alone. The drives have an ultimate static torque capacity of 25 lb. in. with a backlash of 6°. They weigh 4 oz. and 3½ oz. respectively. Furnished in gear ratios of 1:1, 1:2, and 2:1, other ratios are available upon special request.

Circle No. 234 on Subscriber Service Card

Control Rectifier Tester

Power Sources, Inc., is marketing a silicon control rectifier-tester. A sweep supply, a gate supply and a divider for horizontal and vertical are incorporated. The variable sweep supply provides 0-500 volts; the variable gating supply

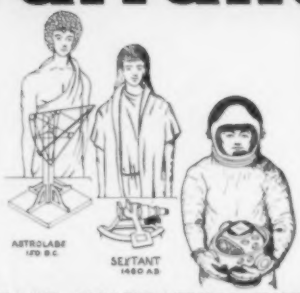
0-7 volts. Vertical output is 50 mv per ma. Horizontal output is 1 volt out for every 5 volts across the unit under test. The unit will test forward leakage, reverse leakage, gate voltage and gate current.

Circle No. 235 on Subscriber Service Card

Differential Amplifier

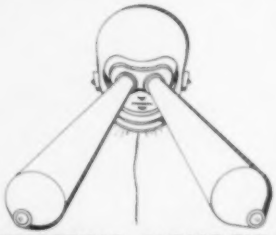
Philbrick Researches, Inc. is marketing the P65 Differential perational Ampplifier. A miniturized plug-in, the P65 has a direct-coupled input circuit with a differential input of 10 volts and com-

Farrand



STELLAR NAVIGATION SYSTEM OPERATES ACCURATELY . . . EVEN IN DAYLIGHT AT SEA LEVEL

In the science of navigation, Farrand pioneered the only working daylight image orthicon star tracker which operated on stars of +3.0 visual magnitude with 2 arc second accuracy at *sea level*. These trackers were first used in the Polaris Missile program in 1957. Farrand has since advanced the state of the art in miniaturized stellar-inertial navigation systems.



OVERLAPPING MONOCULARS GIVE UNIQUE VISUAL CAPABILITY

The Overlapping Monoculars is a unique invention developed and manufactured by the Farrand Optical Company. The device preserves man's wide, unaided field of view in periscopic instruments without any variation of magnification across the field of view. The small entrance pupils, the wide, linear, uninterrupted field of 140° horizontal and 90° vertical, extent and its relatively light weight make this instrument particularly attractive to space tasks.

. . . METROLOGY

Where alignment, position readout or associated mensuration problems exist, Farrand Optical Company offers a complete line of off-the-shelf items such as alignment telescopes, vertical levelling mirrors and a host of associated equipment.

Farrand's activities in the area of electronics and optics can only be very lightly covered in these few examples. A multitude of Farrand designs in communications, optics, sights, trackers, photography, detection, navigation, television and many other fields are covered in our NEW CAPABILITIES BROCHURE. SEND FOR YOUR COPY TODAY.

Farrand

OPTICAL CO., INC.

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New York 70, New York

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3M Materials Memo

News of materials for the aerospace industry – selected from the 27,000 products of the 3M Company

A SIGN OF THE TIMES

In this troubled old world full of bad omens and forebodings of doom, a good sign is a mighty welcome thing. Even when that sign is only an aluminum emblem or identification plate, it's gratifying to know that it can be made – and will perform without causing you grief. In fact, we'll go a step further to say that making and using sign plates from our "Scotchcal" Brand Photosensitive Metal Label is a real breeze. With it, you can literally bring the metal label making capability in-house, where you've got full control. No more delays or premium charges because yours is a low quantity order. Best of all, you can have this capability without investing in a raft of special equipment.

Here's how it works. Using conventional photo-copy techniques, you make a positive or negative film from your original art. (Even without a camera, you can still make direct or reverse copy films from your original with "Scotchcal" Brand Photosensitive Exposure Film by direct contact printing.) From here on, it's just a simple contact printing routine on the metal label using most any ultra-violet emitting light source. Development is merely a matter of swabbing the label surface with a single solution. What's more, no darkroom is needed. "Scotchcal" Brand Metal Label can be safely handled in subdued light.

To apply the finished label to a clean dry surface, you strip the protective liner from the back of the adhesive, press it in place and that's it. The result is an aluminum label that's durable and weather resistant. It's high in fade resistance and stands up well to gasoline, oil and other hydrocarbons as well. Sign up for the full story.

UNSTABLE DIMENSIONS YOUR PROBLEM?

When those dimensions are personal ones like the distance around the midriff, there's cause for irritation—but certainly not alarm. A generous portion of will (or won't) power will usually bring things back in line. But in precision templates, patterns or even chart grids, dimensional variance can easily scuttle the whole operation. Here the answer lies not in control, but in picking the proper stock material in the first place.

PHYSICAL PROPERTIES OF TEN MIL FILM
TENSILE AND ELONGATION

Lengthwise Direction	
Yield point (lb./inch width)	129
Elongation at yield point %	4.0
Break point (lb./inch width)	208
Elongation at break point %	110.2
Crosswise Direction	
Yield point (lb./inch width)	158.5
Elongation at yield point %	4.3
Break point (lb./inch width)	200
Elongation at break point %	160
MULLEN BURST TEST	
Pounds per square inch	445

Where precise printed impressions are concerned, it's pretty hard to beat our PRINTING PRODUCTS DIVISION's "Scotchprint" Brand film. Made in calipers ranging from 2-10 mils, it's in a class of its own in dimensional stability. The change in any direction is less than 2.0×10^{-5} inches/inch for each °F or each % change in relative humidity. Printability too is top notch – either on "Scotchprint" in an opaque paper-like form or as a translucent material. What's more, these impressions can vary all the way from delicate lines to half tones and solids. Like to see "Scotchprint" with a light sensitive coating – or a pressure sensitive adhesive? It's no problem.

"Scotchprint" film is a rugged performer too in quite a few ways. As a 10 mil film, it has a break point of 208 lbs./in. width. It resists even boiling water, mildew, oil, many solvents and chemicals – and repeated creasing won't crack it. Check the coupon below to learn how "Scotchprint" can keep your problem in its proper proportions.

TO BOND OR NOT TO BOND?

"To be or not to be, that is the question." In Shakespeare's day, they rattled swords. Today they rattle missiles. Now the question becomes, "To bond or not to bond?"

"Reduce the weight and increase the strength" is the "hue and cry" in both aircraft and missile design. This means thin, strong, and often stressed skins subjected to maximum loads and extreme fatigue. Traditional methods of metal joining just won't meet the need. So – it's research to the rescue with the chemical bond.

A new technical brochure, available from our ADHESIVES, COATINGS & SEALERS DIVISION, presents the principles of structural bonding. It points out that mechanical fasteners (bolts, rivets, etc.) require holes which weaken skins and result in stress concentrations. Welding and brazing can ruin heat treatments or distort parts. Conversely, structural adhesives distribute loads evenly over joint areas, seal as they join, and open new horizons of fatigue resistance. As an added bonus, the 12 page brochure contains a packet of data sheets on the 3M structural adhesives that helped change the old art of adhesive bonding to the new tool of the structural engineer.

If you would like a copy of this "Scotchweld" Brand Structural Adhesive brochure, check the box below or ask for one from your local ADHESIVES, COATINGS & SEALERS DIVISION representative.

Missile Industry Liaison – Dept. VAB-111
Minnesota Mining & Manufacturing Company, St. Paul 6, Minn.
Please send more information on:

- ☐ "Scotchcal" Brand Photosensitive Metal Label
- ☐ "Scotchprint" Brand Film
- ☐ "Scotchweld" Brand Structural Adhesive
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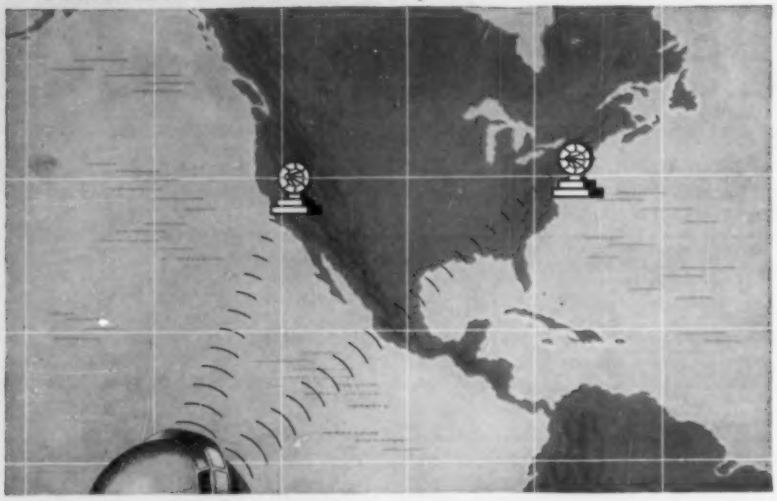
Missile Industry Liaison 3M COMPANY

PERFORMANCE REPORT/PROJECT ADVENT



ASSIGNMENT: design, build, manufacture, install and commission two entire ground control stations under direction of the USAAMA and Sylvania Electric Systems division. **TOLERANCES:** critical beyond precedent! Radar accuracy to within 0.002° of arc, despite temperature expansion of metal components. **SCHEDULE:** completion within one year from declaration of intent! **PROGRESS:** first phase delivered 3 weeks early; current phases on schedule. **SUMMATION:** successful execution on our portion of Project ADVENT demonstrates the ability of Ets-Hokin & Galvan to handle challenging and difficult projects. Call us, at any of these locations, for full information on our capabilities.

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PERFORMANCE **NOW** FOR SPACE AGE DEMANDS

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How good is OPTISYN®?

Here are some of the facts . . . you be the judge.

OPTISYN is an incremental shaft-angle transducer, capable of generating 2048 (or more) precisely-placed counting pulses per input shaft revolution in tiny Size 11 (1.1 inch case diam.); over 4000 counts per turn in larger sizes. OPTISYN has no gears, no sliding contacts. It can produce 100,000 reliable pulse counts per second, at shaft speeds up to 30,000 rpm! Counters have trouble keeping up with OPTISYN.

Sizes 11, 23, and 27 in growing OPTISYN line.

WHAT'S THE SECRET? OPTISYN is based on a unique OPTICAL GEARING principle that results in 4-times increase in resolution, dependable wide-aperture optics, and valuable error-averaging. Accuracy and reliability are the result. OPTISYN is standard equipment on Titan missile, offers 6 years mean-time-to-failure, and ruggedness to meet MIL-E-5272C.

VARIATIONS? Special designs, including pancake shapes, are in production for inertial accelerometers, gyro gimbals, pedestal mounts, industrial uses, etc. Output electronics also available to match high-performance OPTISYN into your digital system. Want more information?

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Tel. 438-3900
Inertial and Industrial Control System Specialists

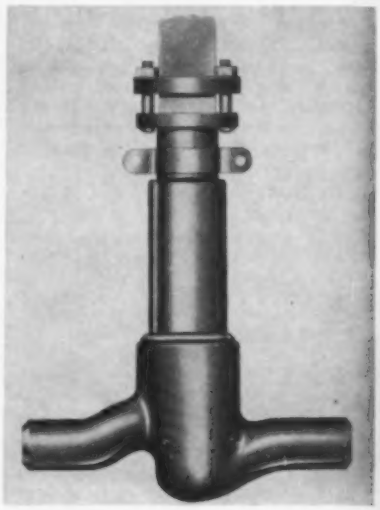
. . . products and processes

mon mode rejection of about 10,000 to 1. Input current is approximately 10^{-7} amperes, which can be balanced out to 10^{-8} amperes with external circuitry.

Circle No. 236 on Subscriber Service Card

Hot Helium Valve

A hot helium valve, designed to operate at temperatures up to 1600°F, is available from Security Valve Co. Valves come either in solid body angle or globe pattern and feature all-welded



construction. Additional features include bellow seals, auxiliary stuffing box and vent connection. This new valve is available in all ASA ratings and sizes as well as a wide range of standard and special body connections.

Circle No. 237 on Subscriber Service Card

One-Megacycle Flip-Flops

Navigation Computer Corp. is marketing the M10 One-Megacycle Flip-Flop Module. This basic module has five identical flip-flops which will operate as a counter at rates up to 2 megacycles. Each flip-flop has a neon indicator. Together with a Model M11 Interstage Delay Module, the M10 forms a parallel-entry adder which will complete a 5-bit addition in a maximum of 4 microseconds. The sum in the adder can be shifted for serial-parrelled multiplication.

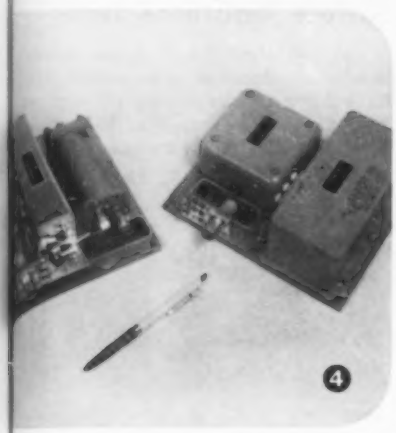
Circle No. 238 on Subscriber Service Card

Explosion-Proof Switch

The Model 610GE Explosion-proof Pressure Switch is being marketed by Custom Component Switches, Inc. The unit is only ¼ the size of similar switches currently available. The Model

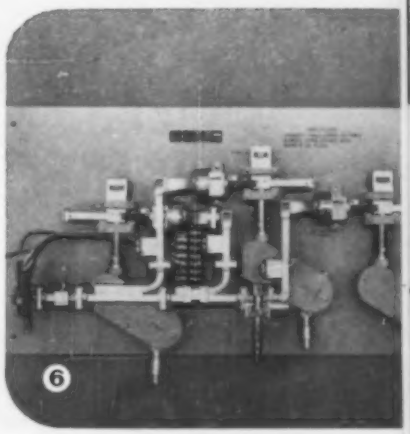
Circle No. 34 on Subscriber Service Card

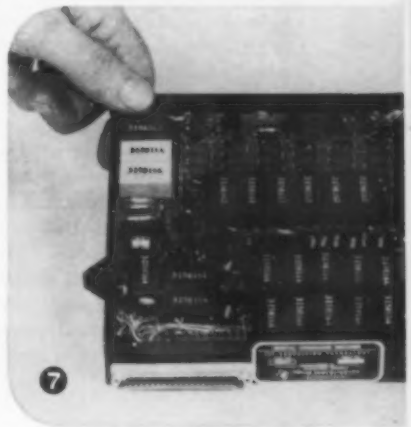
HERE'S HOW TI SOLVES SPACE COMMAND/GUIDANCE PROBLEMS



With **experienced** systems engineering staff–**complete** manufacturing capability–**product-proved** research and development laboratories–plus **time-tested** equipments now operational, some of which are:

1. Command System Ground Checkout Equipment for Jet Propulsion Laboratory, California Institute of Technology, to test Ranger 3-5, NASA lunar probe.
2. Solid-State FM/FM Telemetry Transmitters operated in Mercury spacecraft flights.
3. Flight Data Encoder uses high/low-level PCM telemetry system . . . with ±0.5% accuracy, nulled-out drift. A similar 70-channel system has been supplied to Jet Propulsion Laboratory for Mariner A.
4. Solid-State UHF Beacon Transponder made possible missile tracking by MIT Lincoln Laboratories Millstone radar.
5. Digital flight controller/programmer in Douglas Aircraft's Delta Launch vehicle helped orbit NASA weather satellites Tiros II and III, communication satellite Echo I, space probes Explorer X and XII.
6. 3-Channel Parametric Amplifier—Low-noise operation for C-Band monopulse satellite tracker for Bell Telephone Laboratories.
7. Digital Command Decoder for Ranger 3-5 lunar probes.





For information on your specific command/guidance requirements, contact MARKETING DEPARTMENT.

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Only the skill that comes from many years' experience provides the master craftsman touch that enables Blaw-Knox antennas to be built . . . to the close surface tolerances and to the fine pointing accuracies required by our customers. And Blaw-Knox engineering assures the right design to make the best use of those skills and Blaw-Knox unique shop facilities.

Blaw-Knox designs and builds to close tolerances, with minimum deflections, at reasonable cost—fabricates in steel, special alloys and aluminum—designs to your needs, or builds to your specifications. Complete research, engineering, testing and fabricating facilities are at your disposal. Write or phone today for immediate attention. Blaw-Knox Company, Pittsburgh 38, Pennsylvania. Phone, STerling 1-2700.

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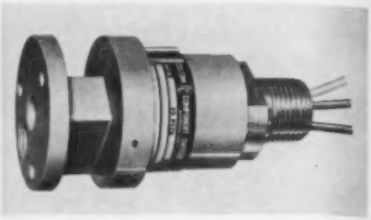
. . . products and processes

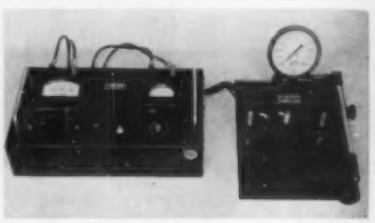


610GE is listed by Underwriters' Laboratories, Inc. for use in hazardous locations Class I Groups A,B,C and D as well as Class II Groups E,F, and G. The CC Dual-Snap switch design provides a positive setting and eliminates drifting of actuation point due to varying temperatures. The CC Dual-Snap switch is not affected by pump ripple or pulsation.

Circle No. 239 on Subscriber Service Card

Surface Resistance Tester

In instrument which checks cleanliness of aluminum or other metals prior to welding by measuring the surface resistance in microhms is available from J. W. Dice Co. A low surface resistance



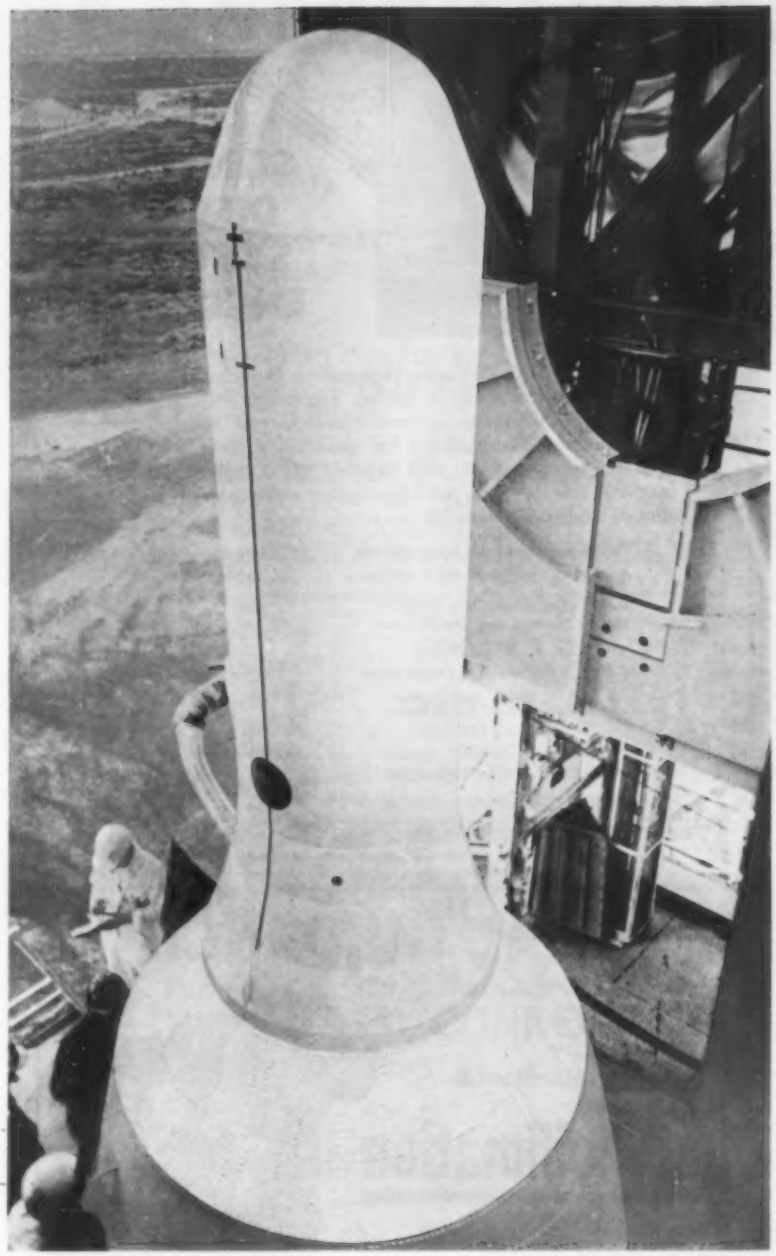
shows that oxides or other contamination have been properly removed and that the material should weld properly. The unit operates on 115 volts, a-c and meets Mil-spec 6858-A. The test jig is hydraulically operated and its capacity range of 0-2000 lbs. permits duplication of the actual pressures used for the welding operation.

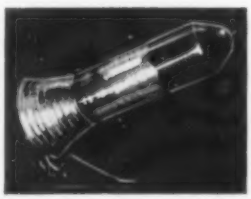
Circle No. 240 on Subscriber Service Card

SPDT Relay

Fast switching and stable contact resistance over long life are combined in a single-pole, double-throw, reed-type relay designated Magnereed Class 103, available from Magnecraft Electric Co. The entire switch element, including gold SPDT contacts, is her-

HITCO-developed fabrication techniques are now providing portions of the heat shield for production Atlas and Titan nose cones





ABLATIVE MATERIALS ENABLE FIRST ICBM NOSE CONE RECOVERY
This RVX1-5 was the first nose cone to travel full ICBM range and be successfully recovered intact. Speeds up to 15,000 mph, temperatures to 12,000°F, high heat inputs, and high acceleration and deceleration forces were encountered. The RVX1-5 was enabled to withstand these severe re-entry conditions through the use of REFRASIL[1] and AVCOITE[2] ablative heat shield materials.

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[1]*REFRASIL is a registered trade mark of H. I. THOMPSON FIBER GLASS CO.* [2]*AVCOITE is a registered trade mark of the AVCO CORPORATION.*

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CONTROL–DISPLAY SYSTEMS ENGINEERS

The Advance Engineering Division of Lear, Incorporated, is further expanding its activity in Control-Display Systems research and development. Openings are available for qualified systems engineers who are interested in, and capable of, designing efficient man-machine systems, with particular emphasis on manned aircraft and space vehicles.

A background in instruments, flight dynamics, and human performance is desirable.

Qualified engineers are invited to submit resumes and inquiries to:

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The KERN DKM2

When equipped with the new No. 356 Autocollimating Eyepiece, this famous one-second theodolite has a total magnification of 23x and an operating range from zero to at least 100 feet for autocollimation.

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...products and processes

metically sealed inside a glass capsule in an atmosphere of inert gas. The contacts are actuated magnetically by a coil around the glass switch capsule. The construction is extremely simple and the relay is readily adaptable to all kinds of mechanical configurations.

Circle No. 241 on Subscriber Service Card

Waveguide Switch

A new approach to the internal choke design of a waveguide switch has enabled NRK Microwave Division of Cook Electric Co. to develop a high-power miniature waveguide switch which is smaller in size yet comparable in performance to conventional switches. NRK Microwave is marketing switches of this design to cover the frequency range from 5.85 to 18 Gc. The X-band switch for use with RG67/U guide has a maximum VSWR of 1.10:1 minimum isolation of 50db and 0.10 db insertion loss and 250 KW peak power handling capability at 1 atmosphere from 8.5 to 9.6 Gc.

Circle No. 242 on Subscriber Service Card

Static Frequency Changer

A 10-KVA, 3-phase, 115/200-volt static frequency changer is available from Precision Power Division of American Electronics, Inc. Operating from a 60-cycle 220 or 440-volt source, Model 361-102-103 frequency changer provides fixed or continuously variable

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NOVEMBER 27, 1961
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output frequency of 400 ± 50 cycles and variable output voltage of 115 ± 15 volts. The unit is capable of maintaining both the output frequency and voltage at any setting to within ±1% under conditions of changing output load from no load to full load and changing input frequency and voltage of ±5%. Average harmonic content is 3% with a maximum harmonic content of 4%.

Circle No. 243 on Subscriber Service Card

Coaxial Isolator Line

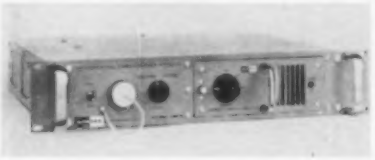
E & M Laboratories is marketing a series of lightweight coaxial isolators. These isolators are lightweight units which meet MIL specification standards

over a temperature range of −30°C to 85°C. Standard units are available in the frequency range of 0.95 KMC to 3.1 KMC. A typical unit is the 2.2 to 2.3 KMC isolator which is 5.0 in. long, weighs a maximum of 6 oz.

Circle No. 244 on Subscriber Service Card

D-C Preamplifier

Cohn Electronics, Inc., Kin Tel Division, is marketing a differential d-c preamplifier, floating and narrow-band, for general use. The Kin Tel 459 C/N, with the gain set at −100, extends the range of Kin Tel Digital voltmeters to 1 microvolt d-c and pro-



vides stable, accurate amplification of low level input signals in the presence of high common mode noise and hum. Common mode rejection is 180db for d-c and 130db for 60 cps with up to 1000 ohms unbalance in either signal lead.

Circle No. 245 on Subscriber Service Card

Ballistic Plate Developer

A transportable, Semi-Automatic Film Developer that can be used in either lab or field work, has been designed by Instrument Corp. of Florida. The instrument permits the unloading of cassettes in daylight, thus eliminating the need for darkrooms. The compact, lightweight developer features indicator lights on panels for visual determination

Spectacular as it is, a Titan take-off from Canaveral is only one end of the story. Moments after the shoot, nine thousand miles downrange, an airborne monitoring team is alerted to record the other end of the story as the re-entry vehicle plunges into the atmosphere at 15,000 mph.

Aboard the re-entry monitoring aircraft, a battery of photographic, photoelectric, and radiometric devices captures the dramatic end of the flight. A P.I. instrumentation tape recorder, operated by an Avco-Everett Research Laboratory monitoring team, is used to preserve on magnetic tape a precise record of important radiometric and time-sequence information... data which is essential in the development of advanced re-entry vehicles and in the country's anti-missile program.

One reason a P.I. recorder was selected for this program is that it provides full-size instrumentation performance in a fraction of the space. You'll be interested, if you record any type of scientific data, in other characteristics of P.I. recorders. For details, write for our current brochure.

Above — Photo of Titan missile re-entry. Below — Recorder installation aboard the monitoring aircraft. Photos courtesy of Avco-Everett Research Laboratory.

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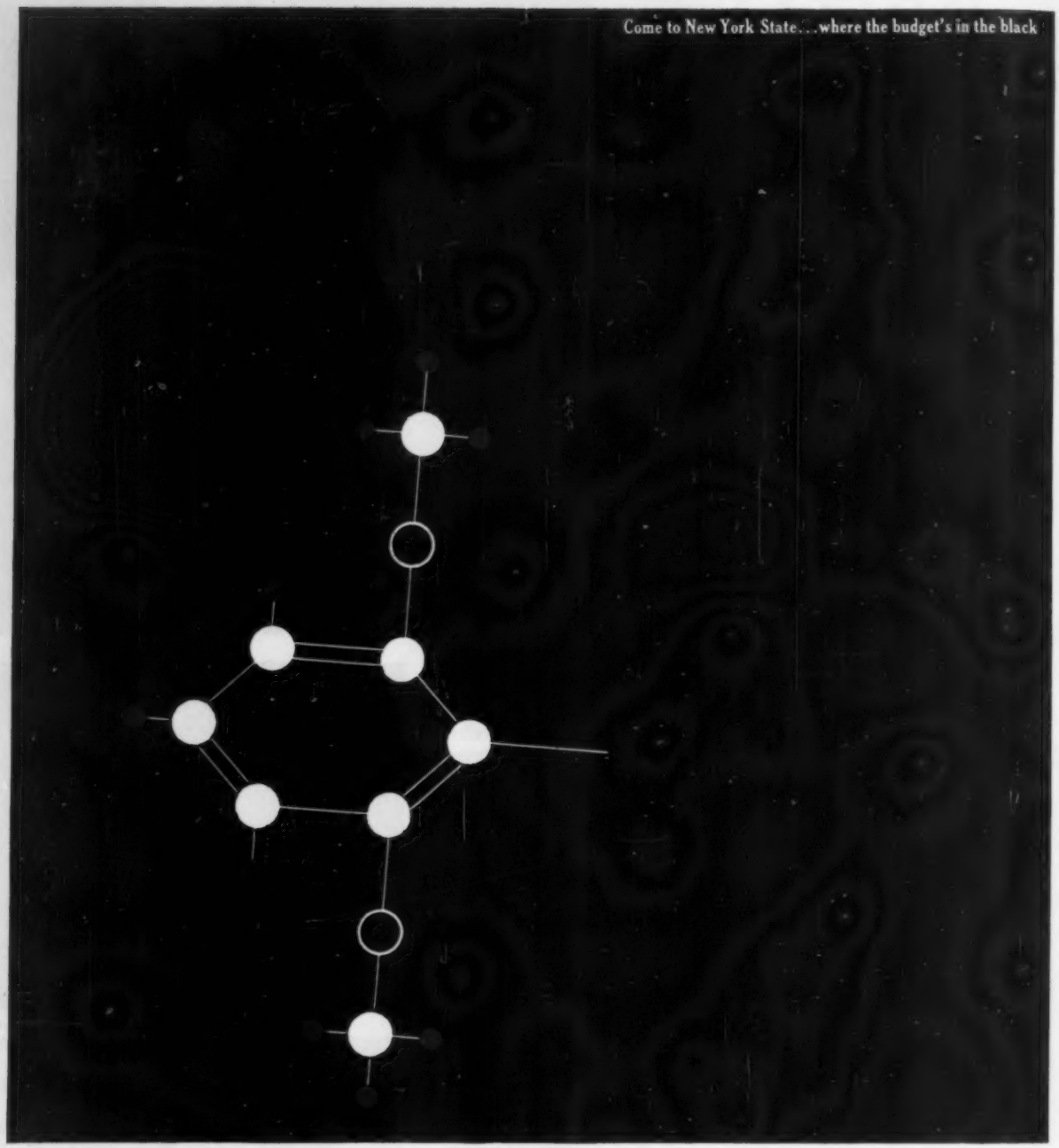


1,000 RESEARCH CENTERS MAKE SCIENCE BIG BUSINESS IN NEW YORK STATE

The most stimulating climate for science in America today is in New York State. New research and development centers are going up at an unprecedented rate. Currently there are more than 1,000 such centers at work in atomic energy, electronics, communications, pharmaceuticals, product development and other fields. Their work determines the future of industrial growth and prosperity. The 71,000 scientists, technicians and administrative assistants in these centers represent the nation's greatest concentration of research talent. And it's enhanced each year as New York's 170 colleges turn out America's largest crop of young scientists and engineers. Come, build your laboratory or research center in this invigorating environment. Here you'll find the skilled personnel you need right at hand. The equipment and other facilities you must have are here, too. Equally important, you'll be in an area with good schools for your children and exceptional cultural and recreational opportunities.

We will prepare for you – without cost or obligation – a confidential survey of proposed plant sites, selected to fit your needs. Outline your requirements on your business letterhead and send them to Commissioner Keith S. McHugh, Department of Commerce, Room 2303, 112 State Street, Albany 7, New York.

N.Y.S.

Circle No. 99 on Subscriber Service Card

NATIONAL WATER LIFT COMPANY DIVISION

Subject: Servo-Valves

Pitch, Yaw, Roll, Control System / Mercury Capsule / Designed / Developed / Produced.

SYSTEMS ENGINEERING DIVISION

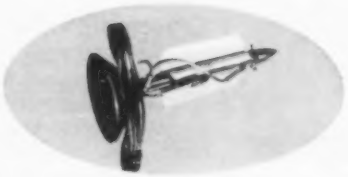
Subject: Thrust Vectoring

Thrust Vector Control System under Development for Polaris Missile Application.

INSTRUMENTATION AND CONTROL DIVISION

Subject: Two-Axis Controller

Controller for X-Y Coordinates of Two-Axis Control System Designed/Developed/Produced for Nortronics/ for Control System of Polaris Submarines.



ADVANCED SYSTEMS DEVELOPMENT DIVISION

Subject: Imbedment Anchors/Sea Staple

Designed / Developed in Family of Sizes with Holding Powers 350 / 300,000 lbs. / Anchor Permits Mooring of Variety of Marine Hardware in Precise Locations at any Depth of Water / Mark II and V Anchors now off the Shelf.

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DIVISIONS

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Circle No. 100 on Subscriber Service Card

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Cast aluminum receptor; twin fountain heads direct automatically regulated streams into the eyes.

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Sensitive eye tissue can be destroyed in moments. Contamination from industrial caustics and chemicals requires instant first aid . . . and a HAWS Emergency Eye-Wash Fountain can mean the difference between temporary irritation and permanent injury! Write for your free HAWS catalog.

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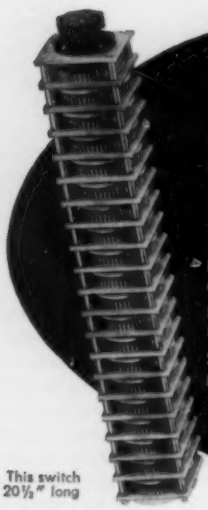
FOR THE FIRST TIME



UP TO 20 DECKS WITH 160 POLES

In Precision Instrument Switches — Through accurate, automatic alignment with low drag

CHANGEABLE DECKS — Captive Rotor gives integrated deck assembly—Switch can be disassembled, wired, decks exchanged, reassembled—quickly, easily, with common socket wrench.

LOW RESISTANCE—Fine Silver brushes and contacts—Lowest contact resistance of 1.3 milliohms — ideal for dry circuits.

LONG LIFE—Rugged. Low Contact Pressure with self equalizing brush design withstands up to 50G shock with 50% longer life.

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FREE— Write today for 24 page Guide to Choosing Precision Instrument Switches

This switch 20½" long

Langevin *A Division of Sonotec Incorporated*

503 SOUTH GRAND AVENUE • SANTA ANA, CALIFORNIA

Circle No. 36 on Subscriber Service Card

...products and processes

of the various stages of development process. An adjustable timer permits developing from 30 seconds to 7½ minutes—1 minute for shortstop—up to 15 minutes for hypo—and 15 minutes to an indefinite time for wash. A dryer is also incorporated into the unit.

Circle No. 246 on Subscriber Service Card

Low Level Multiplexer

A transistorized Multiplexer capable of commutating differential or single ended input signals from 0 to + 15 volts, with a resolution to one microvolt is available from Alpha-Tronics Corp. Over variations in source impedance of 0 to 10K ohms and −20°C to + 85°C, the offset voltage of the Multiplexer does not exceed 50 microvolts and the saturation resistance is less than 40 ohms. The unique sequencer employed guarantees that two switches cannot be gated simultaneously, even with a component failure.

Circle No. 247 on Subscriber Service Card

Cryogenic Level Control

Powertron Ultrasonics Corp. is marketing the Sonoswitch, Model UP 1015, that affords complete automatic control for all cryogenic liquid control applications. The stainless steel probe instantly activates when any cryogenic liquid touches its sensitive probe surface. The unit has repeatability within thousandths of an inch and is not affected by clinging droplets. The ultrasonic probe, capable of operating at a pressure over 2000 psi, does not actuate in either foam or froth and requires no adjustment for temperature shifts or pressure variations.

Circle No. 248 on Subscriber Service Card

Accelerometer Switch

For measurements of steady-state acceleration, Humphrey, Inc. has developed the AS31 series Accelerometer Switch. The unit offers rapid response time to steady-state accelerations together with insensitivity to low frequency vibration. This performance was achieved by incorporating a high damping factor and a low natural frequency into the design. Reliable operation over a wide temperature range is ensured by the use of temeprature-stable air dampers and flexure suspension. The AS31 Series of accelerometer switches covers ranges of ±1G up to ±50 G's and may also be made for even higher ranges.

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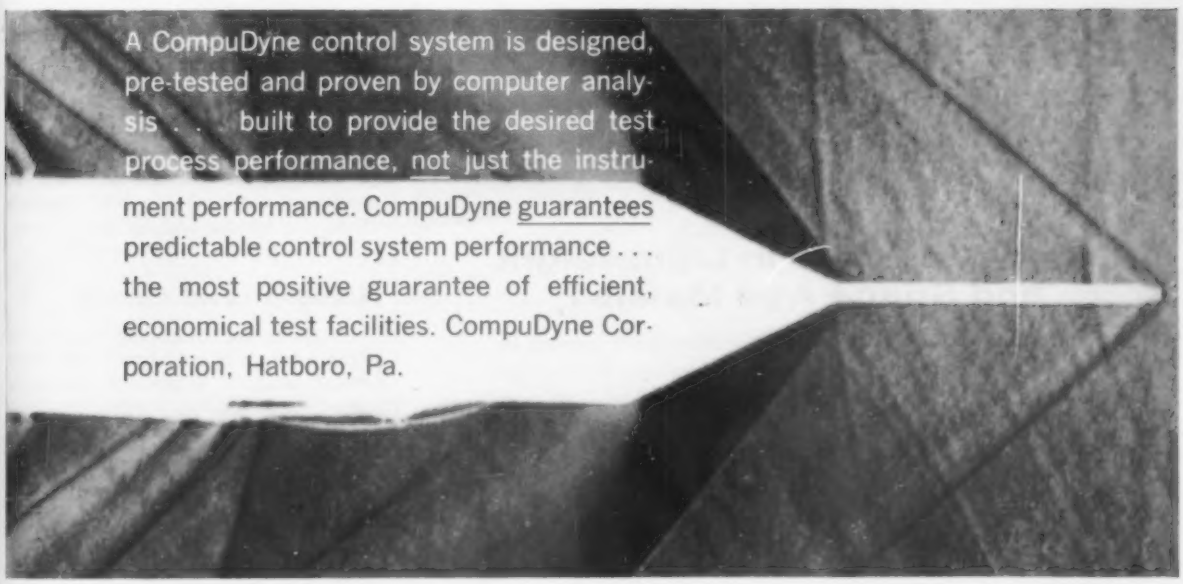
Pulsed X-Ray System

A multiple pulse X-ray system capable of charting the performance of

DATA, DOLLARS AND TIME:

Each is a vital factor in the accelerated program to increase performance efficiency of missile and aeronautical test facilities. CompuDyne control systems apply dynamic control to critical variables inherent in aerodynamic structural and other test procedures to promote the output of more information, in a more useable, valid form —at a fraction of the time required with costly steady-state systems.

Thus, a CompuDyne control system in a blow-down wind tunnel integrates precise, dynamic control of air velocity and pressure with a programmed positioning sequence of the model being tested. Result: greatly increased data output per test run. Equally effective results have been achieved for many NASA installations using CompuDyne systems including rocket engine test cells, structural load test facilities, space environmental and sonic test facilities, and missile fuel loading equipment.



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CompuDyne Corporation manufactures computer-operated automatic control systems and related electronic, hydraulic, and mechanical instrumentation for the aircraft, missile, space, and industrial process fields.

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61-T-6

...products and processes

totally enclosed moving parts is available from MB Electronics. The pulsed X-ray system was developed by Zenith Radio Research Corp. It is being marketed in the environmental testing field by MB. The depth studies now possible should be instrumental in developing new information and techniques of value to the environmental engineer. The end result should be increased product reliability through decreased test time and expense.

Circle No. 250 on Subscriber Service Card

Cycle Counter

A combination portable unit, designed for high-speed time interval and cycle counting, is available from Astro-Space Laboratories, Inc. It uses transistorized, printed-circuit plug-in modules, with a crystal-controlled oscillator for stable time base. The TC-1 has a self-contained power supply. Input signals may be from a photohead or from auxiliary sources. Operating range of the timer is preset via counter response, over a time interval of 999.999 seconds in 1 msec. steps. Maximum repetition rate of the preset counter is 110 kc, with a capacity of up to 999 cycles.

Circle No. 251 on Subscriber Service Card

Wire-Fed Torch

A wire-fed 22-oz. welding torch, is available providing significant improvements in maneuverability and coolness. Developed by the Westing-Arc Department, Westinghouse Electric Corp., the straight-through torch, Model HT-1 has a rated 100% duty cycle of 200 amps, and accommodates wire sizes from .030 in. to .047 in. It can be used with CO_2 in the reactor and spray ranges, and with argon or argon gas mixtures in the reactor range. A nozzle-seat design allows 360° rotation about the handle without using tools.

Circle No. 252 on Subscriber Service Card

Nitrogen Level Control

A system for controlling the level of liquid nitrogen in cold traps, and other low-temperature vessels, is available from Cryogenics, Inc.

The Cryotrol is designed around a

NOTICE TO MISSILE SYSTEM SUPPLIERS

Any equipments or components you are producing for missile weapons systems can be analyzed for Radio Frequency Interference by Capehart's INTERDICT* Group. Under our analysis procedures, RFI is computer-predicted on finished products, prototypes, or preliminary designs. Every item of electronic equipment which produces radiated or conducted RF signals is considered a transmitter, and every electronic equipment which is subject to malfunction as a result of exposure to conducted or radiated spurious signals is considered a receiver.

We will make specific recommendations and provide design changes to bring your equipment within the RFI specifications or inform you if it is already within standards. Capehart's INTERDICT Group performs this same service for any other type of installation, site or system where RFI may be a potential problem. Our approach in RFI diagnosis of over-all operational requirements utilizing computer programming has been proven on a number of electronic equipments, missile systems and military sites including Cape Canaveral and Vandenberg AFB.

* *Interference Detection and Interdiction by Countermeasures Team*

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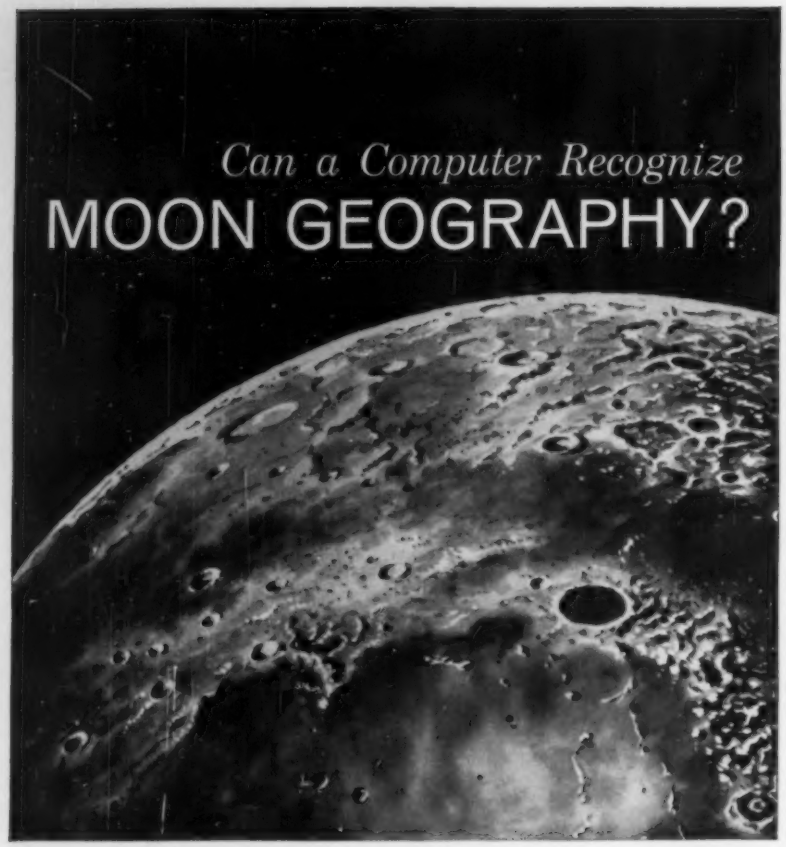

• Cornell Aeronautical Laboratory's engineers and scientists are investigating concepts for computers which can be "taught" to recognize patterns, whether those patterns be airfields, gun emplacements, or even significant topographic features of the moon. Equally important, some of the special purpose computers under development in related areas are surprisingly small, yet faster for the task than the speediest general purpose computers in use today. These computers use novel delay line storage techniques to perform computations in real time. Other related computer sciences activities include analytical and experimental research in data processing techniques, adaptive control systems, and trajectory tracking techniques.

But CAL's pioneering effort in space technology extends into other areas as well. For example, the hypersonic tunnel facilities are among the nation's most exacting and complete for simulating hypersonic flight in the earth's atmosphere. The wave superheater tunnel will produce high temperatures for relatively extended periods (up to 15 seconds), while the shock tunnels extend CAL's research and testing capabilities to duplicate orbital re-entry for relatively brief periods (up to 10 milliseconds).

Our technical team is also making pace-setting strides in electronic packaging for payload development, experimental programs for space propagation research, and wind-shear measurements for launch aid. If you would like to know more about the research capability of this not-for-profit laboratory write or wire J. J. O'Neil. If you believe you are qualified to join the team write Jack Rentschler.

CORNELL AERONAUTICAL LABORATORY, INC.

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...products and processes

unique upper-lower limit sensor mounted in a suitable probe configuration which may be attached to cold traps and process devices. When the level of liquid in the cold trap drops below a pre-determined lower limit, the controller actuates a solenoid valve which in turn initiates transfer of liquid into the cold trap until the pre-determined upper limit is reached. The solenoid control valve is the de-energized and the transfer stopped.

Circle No. 253 on Subscriber Service Card

Gas Regulator

Extremely narrow flow to lockout band, high reliability, and accuracy over broad time lapses have been achieved in a gas regulator available from Vinson Mf. Co. It is compatible with most space fuels and has a temperature range from −100°F to 550°F. In a typical performance with metal seats, inlet

pressure range is 200 to 3600 PSIG, regulated pressure 87 PSI at 2.0 SCFM minimum. Lockout pressure is 104 PSI at 0.5 standard cc per minute maximum. With soft seats, a typical inlet pressure range is 250 PSIG to 4000 PSIG; regulation is adjustable from 125 to 190 PSIG; regulated pressure is 183 PSI at 2.0 SCFM; lockout pressure is 187 at 0.5 standard cc per hour.

Circle No. 254 on Subscriber Service Card

Flat-to-Round Adapter

An adapter device for interconnecting flat conductor cable with conventional round wire is available from The Thomas & Betts Co. An addition to their line of Pos-E-Flex flat cable connectors, this round wire adapter simplifies the introduction of flat cable to existing electrical and electronic equipment wiring systems. The connector makes the use of flat conductor cable a practical reality for low-voltage control wiring, intercom systems and remote control wiring.

Circle No. 255 on Subscriber Service Card

SCIENTIST-MANAGER PhD Physics

Applications of Ion, Arc Jet, MHD and Other Advance Engines to SPACE PROPULSION SYSTEMS

One of the most challenging assignments in space technology—the application of very advanced engines to provide capability for space maneuver and deep space propulsion. This scientist will lead a small group of specialists. Requires doctoral degree in Physics and minimum of 8 years applicable experience, with 2-3 of these in electric propulsion R&D. (A)

SR. STRUCTURAL DESIGN

Establish configuration D&D of re-entry vehicles, missile & space vehicles including application of new materials; determine design allowables and preliminary stress analysis. ME or AE plus 8-10 years structural design experience. (V)

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Diversified Assignments in Systems Engineering

SYSTEMS DESIGN
Navigation & Control (F)

Challenging opportunity for engineer capable of assuming responsibility for integration, coordination and project engineering of special navigation and control systems. These include satellite attitude control, orbit control, space power. Work requires a broad background in controls; 5 or more years engineering experience; EE or ME.

SYSTEMS ANALYSIS
Varied Space Systems (G)

Conduct preliminary studies to optimize space systems through subsystem trade-offs, in order to provide a balanced systems synthesis effort. Define performance requirements and specific interface relationships between sub-systems. Degree plus 4 or more years experience in systems analysis required.

HUMAN FACTORS

Psychologist, MS, PhD, to solve intriguing man-in-space problems. (K)

Research Associate

Interplanetary and Lunar Trajectories

Conduct analytical and computer studies in applied mechanics, applied mathematics, celestial dynamics and analytical dynamics. Requires PhD in any of the following: Mathematics, Astronomy, Applied Mechanics. (P)

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CONSULTANT Space Structures

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THERMO-DYNAMICS

Determine design adequacy of missiles, re-entry and space vehicles with respect to thermodynamics, heat transfer and aerodynamic heating design factors. Conduct parametric studies pertaining to configurations; performance of external protection and internal cooling systems. BSME, AE or ChE with 3-5 years experience. (L)

All qualified applicants will continue to receive consideration for employment without regard to race, creed, color, or national origin.

GENERAL ELECTRIC

Simply circle the appropriate letters of those positions that meet your professional interests and qualifications, fill in the questions listed below—attach a resume if you have one handy—and airmail to:

Mr. Frank Wendt
Missile & Space Vehicle Department
General Electric Company
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Philadelphia 4, Pennsylvania

I am interested in the following position(s)

Vehicle Engineering ..... B, V
Navigation & Control ..... F
Aerodynamics — Trajectories ..... P
Thermodynamics — Aerophysics L
Systems Analysis ..... G
Advanced Systems ..... F, G
Ground & Space Support ..... K
Applied Mathematics ..... P
Space Power & Propulsion ..... A, J
Analog & Digital Techniques ..... P
Life Support ..... K

PROFESSIONAL EXPERIENCE

(Two most recent or most applicable jobs)

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Position_____
Years of experience (from)_____
(to)_____ Salary_____
Assigned Duties_____

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Position_____
Years of experience (from)_____
(to)_____ Salary_____
Assigned Duties_____

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Home Address_____
City_____ State_____
Telephone_____
U.S. Citizen Yes ☐ No ☐

Education

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Degree_____ Year of Graduation_____

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Degree_____ Year of Graduation_____

Position Objective (primary job preference, level of responsibility, salary expectations)

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LETTERS

(Continued from page 10)

Saturn *Should* Succeed

To the Editor:

Let me congratulate you on your Nov. 6 editorial ("Afterthoughts of a Saturnalia").

After the recent *Saturn* shot I feared those involved in the project were going to wind up with bursitis, a condition brought about by patting themselves on the back.

You are the only editor that I know of who has had the guts to write about this disgraceful display of self-love and self-congratulation.

I certainly do not, as I am sure you don't, want to detract one bit from the achievement of those engaged in our space activities.

But, on the other hand, I had been led to believe that America's greatest engineering minds and abilities were engaged in this work. Because of this, I expect successful shots to be the rule, failures the infrequent exception.

William H. Graffis
Wilmette, Ill.

Electronic Warfare

To the Editor:

We here at Hallicrafters, who are involved in electronic warfare, were very much impressed with your articles in the Sept. 25 M/R covering the electronic warfare market.

We felt that your coverage was an excellent job of reporting, and that you approached each detail for the present and future electronic warfare requirements very accurately.

As you well know, we see a great need for electronic warfare equipments in the protection of our manned and unmanned missiles for the future, and we sincerely believe that your articles will draw attention to these needs. . . .

Robert F. Halligan
President
The Hallicrafters Co.
Chicago

Further Re 'B, B & B'

To the Editor:

While we agree with the basics of your editorial "On Booze, Blondes and Bashes" (M/R, Oct. 23), we are quite disturbed that Boeing is the only company mentioned specifically in the editorial. I am quite sure you would agree that we were perhaps the most innocent parties as regards "B, B & B" at Philadelphia. While your mention of Boeing was in connection with another matter, I am afraid that many people will connect us with the basic subject of your editorial.

We have always taken a very conservative view of shows and exhibits and in fact participate in fewer than practically any other company. You may recall that we were the only major company not represented at the World Congress of Flight

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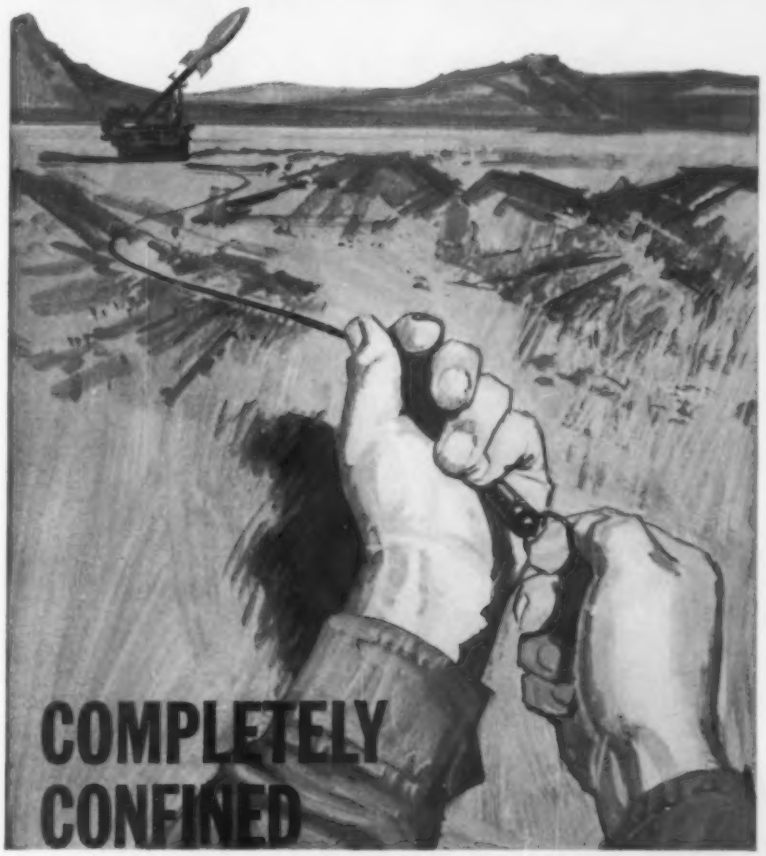

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...letters

in Las Vegas. My head is still bloody from that one, but I still believe we were right.

Carl M. Cleveland
Director of Public Relations
The Boeing Company
Seattle

We did not hesitate to mention Boeing's name because, as we can state from many years of experience, Boeing is known and respected throughout the industry as one of the most conservative firms in this regard.—Ed.

To the Editor:

We agree completely with the concluding paragraph in your editorial. There should be fewer meetings, better papers and less booze, and it would improve the industry image. But this is like being against crime and sin and in favor of motherhood. Everyone agrees.

You know there are good advertisements and good exhibits and even good editorials—just as there are bad ones. Using overdrawn examples as you have done is applying a tar brush to everyone.

We aren't complaining, either. We were just wondering what a "whacking sum" for a display is? And why was the Boeing display an "obviously" expensive one? (Your statistics are a little puzzling, too, but a current *Fortune* article has more to say on that subject.)

The survey by Clapp and Poliak was a fine, constructive piece of work. We in the exhibit industry welcome such efforts toward improvement. Let us have more of that kind of material. We, along with such reputable concerns as they are, will continue working to make our medium live up to its ability as the most effective and worthwhile selling tool available—as it has been for centuries, throughout the world.

Roger R. Tierney
President
Floats, Inc.
El Monte, Calif.

To the Editor:

Just read your editorial in Oct. 23rd issue on "On Booze, Blondes and Bashes" . . . Congratulations!

Here's one small voice crying in the wilderness that agrees wholeheartedly with you. I've "slept" through many papers. Just had to let you know there are other who feel the same way about the subject.

Daniel J. Walsh
Press Relations
General Precision, Inc.
Tarrytown, N.Y.

To the Editor:

The second and third reading of "On Booze, Blondes and Bashes" in your 23 October issue has convinced me that I want to circulate this to several people in our company who may not have seen it. If it isn't too much trouble please send me fifty reprints of that editorial and bill me for them.

E. S. Thompson
Defense Field Operations Dept.
General Electric Co.
Los Angeles, Calif.

—names in the news—

Dr. S. Dean Wanlass: Elected president of Packard Bell Computer Corp. In addition to his new post, he will continue to serve as group vice president-Defense and Industrial Group of the parent Packard Bell Electronics Corp. Other new officers named by the board are **Kenneth R. Jackson,** vice president and director of administration; **William Seiden,** vice president and director of manufacturing; and **Theodore J. Smith,** vice president and director of marketing. **Lowell R. Day** continues as treasurer and **William H. Moore** as secretary.

John F. Jacobs: Named assistant vice president—Technical Operations for the Mitre Corp. He will share with the vice president of Technical Operations the responsibility for policy and the active technical management of Mitre's many system engineering programs. Prior to joining Mitre in 1958 Jacobs spent six years at MIT in various system engineering assignments in air defense work.

Dr. David J. Mann: Appointed director of research of the Reaction Motors Division, of Thiokol Chemical Corp., Denville, New Jersey. His new position includes responsibility for directing the total research effort of the division, including the development and synthesis of liquid and solid propellants.

John B. Lawson: Appointed director, administration and manufacturing at Ford Motor Company's Aeronutronic Division, Newport Beach, California. He will have overall responsibility for such functions as industrial relations, finance, public relations, manufacturing, facilities, purchasing and supporting services. Prior to joining Ford in 1949, Lawson was vice president of Ferracute Machine Co., and was business manager and controller of Villanova University.

Henry J. Fitzpatrick: Appointed manager of contract administration for the Vard Division of Royal Industries, Inc., Pasadena, Calif. Fitzpatrick was formerly associated with the Garrett Corp.

Sidney Minault: Named vice president of manufacturing of Dunn Engineering Corp., Cambridge, Mass. He came to Dunn Engineering earlier this year from Northrop Corp. and was previously vice president and general manager of the National Research Corp.'s Equipment Division and vice president and general manager of Tracerlab, Inc.

Dr. John G. Frayne: Appointed manager of the Data Systems Department of the Marquardt Corporation's Pomona Electronics Division. In this capacity, he will be responsible for directing all activities relating to the design and development of data processing and display systems. Frayne has been engaged in the fields of electronics and physics for almost 40 years. Before accepting a position with Mar-

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quardt, he was the manager of the Electromechanical department of Datalab Division of Consolidated Electrodynamics Corp.

R. C. Stiff: Named Senior division manager of a new engineering operations division of the Liquid Rocket Plant of Aerojet-General Corp. Four divisions have been consolidated into the new division, with Stiff heading the set-up. He previously served as manager of the engineering and research division.

Harry W. Burdett, Jr.: Has joined American Machine & Foundry Company's Government Products Group as manager of planning. Prior to his new position Burdett was with Thiokol Chemical Corporation's Reaction Motors division, Denville, N.J. for 16 years, where he worked on long-range technical planning and market research for the design of advanced liquid rocket systems for spacecraft and missiles.

Dr. William T. Clary: Named director of systems research in the information systems department of North American Aviation's Space and Information Systems Division, Downey, Calif. Prior to joining North American he held managerial positions at Aeronutronic and Hughes Aircraft in the electronic systems and aerospace systems engineering and analysis areas.

Alfred A. Blanco: Appointed director of marketing, plans and proposals, at Page Communications Engineers, Inc., a subsidiary of Northrop Corp. Blanco, who has been with Page since 1960, was previously associated with U.S. Army and U.S. Air Force electronic engineering agencies engaged in supervising engineering activities related to long range communications, radar and air navigation systems throughout the world.

E. C. Carman: Named to fill a newly created position, director of marketing, in Avco Corporation's Nashville, Tenn. Division. Carman has been with the company for 13 years in various positions. Prior to joining Avco, he was employed by the Consolidated Aircraft Corp., Tucson, Arizona.

Everett S. Glines: Appointed general manager of Republic Aviation Corporation's Missile Systems Division. Glines, who has been with Republic since 1944, has filled numerous executive engineering positions.

Vaughn R. Chadbourne: Elected president of Air Borne Controls, Sun Valley, Calif. He is a leader in the field of electrical design and will utilize his long experience in expanding the company's capabilities to keep step with its rapid growth. Chadbourne will also remain as chairman of the board of Electronic Sealing Inc. of Sun Valley.

William I. Switzer: Named vice president of Astrometrics, Inc., Santa Barbara, Calif. Backed by extensive experience with Arnoux Corp., North American Aviation and Chance Vought Aircraft, he joined Astrometrics in 1959.

F. R. Zatlin: Named director of program management at Ewen Knight Corporation, with the responsibility of over-all management of both contract programs and independent projects initiated by the company. He was formerly director of engineering and vice president of Johnson Electronics.

Donald W. Chrisman: Appointed director of planning for the Martin Electronic Systems and Products Division, Baltimore. He will be responsible for the division's operational and long-range planning. Chrisman has been with Martin since 1948. Previously, he was with the Farnsworth Television and Radio Corp. and has been with the Federal Bureau of Investigation.

Norman F. Svendson: Appointed to the newly-created position of associate manager of the Support Systems Department, Engineering Mechanics Lab of Space Technology Laboratories, Inc. Svendson, formerly head of the department's Launcher Systems Section, has been with STL for five years.

Gustave A. Linenberger: Named vice president and general manager of Aerojet-General Nucleonics, a subsidiary of Aerojet-General Corp. **Robert Gordon** was named vice president and technical director of the company. Linenberger has been with AGN since 1956, serving as associate technical director and assistant manager of engineering. Prior to joining AGN, he participated in early design and operation of Project *ROVER* experiments.

A MESSAGE FROM KEARFOTT TO EMINENT SCIENTISTS

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Annual International Visual Communication Congress, cosponsored by **Society of Reproduction Engineers, American Institute for Design and Drafting and the American Records Management Association,** Biltmore Hotel, Los Angeles, Dec. 2-5.

National Aerospace Support and Operations Meeting, sponsored by **Institute of the Aerospace Sciences,** San Juan Hotel, Orlando, Fla., Dec. 4-6.

19th Annual Electric Furnace Conference, the Metallurgical Society of AIME, Penn-Sheraton Hotel, Pittsburgh, Dec. 6-8.

Eastern Joint Computer Conference, sponsored by **IRE-PGEC, AIEE** and **ACM,** Sheraton Park Hotel, Washington, D.C., Dec. 12-14.

Annual Meeting, American Association for Advancement of Science, Denver, Dec. 26-31.

Annual Meeting, American Statistical Association, Roosevelt Hotel, New York City, Dec. 27-30.

JANUARY

8th National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D.C., Jan. 9-11.

National Plant Engineering and Maintenance Show and Conference, Convention Hall, Philadelphia, Jan. 22-25.

Solid Propellant Rocket Conference, ARS, Baylor University, Waco, Tex., Jan. 24-25.

FEBRUARY

Western Electronic Week and Pacific Electronic Trade Show, Las Vegas and Los Angeles, Feb. 3-11.

Winter Convention on Military Electronics, IRE, Ambassador Hotel, Los Angeles, Feb. 7-9.

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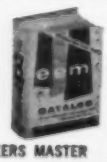

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contracts

AIR FORCE

$15,380,000—**Thiokol Chemical Corp.**, Bristol, Pa. for stage 1 engines and related equipment for *Minuteman* ICBM.

$3,725,000—**General Dynamics Corp.** for *Atlas* missile trainers and for continuation of design, development and fabrication of the *Centaur* booster. (2 contracts)

$3,649,440—**General Electric Co.**, West Lynn, Mass. for missile trajectory measurement system.

$3,068,000 — **American Bosch Arma Corp.**, Garden City, N.Y. for *Atlas* missile guidance sets.

$2,123,330—**Avco Corp.**, Wilmington, Del. for development, fabrication and test of decoys for the *Nike-Zeus* target support program.

$2,000,000—**Aerojet General** for additional work on the *Minuteman* engine.

$1,200,000 — **Douglas Aircraft Co.**, Santa Monica, Calif. for production of ground equipment for *Skybolt* missile.

$327,000—**Thompson Ramo Wooldridge**, Los Angeles, for electronic equipment to be used in a system to assist in making command decisions.

$300,000—**Cohu Electronics, Inc.**, San Diego, Kin Tel Division, for closed-circuit television systems for the *Titan ICBM*.

$89,255—**B. D. Collins and Charles Fletcher**, Lompoc, Calif. for modification of 75-1 complex pad No. 1 at Vandenberg AFB.

$79,996—**Cornell Aeronautical Lab., Inc.**, Buffalo, for continuation of research studies of high-temperature phenomena in hypersonic flows.

$37,585—**Technical Operations, Inc., Washington Research Office**, D.C., for study to determine preliminary estimates of the data flow and machine requirements for processing Project *VELA* uniform data.

$35,640—**Stanford University**, Calif., for continuation of studies in hypersonic flow theory.

$33,694—**Adcole Corp.**, Cambridge, Mass., for design, construction and testing of portion of payload for *Nike-Cajun* type report.

ARMY

$4,542,226—**Bendix Systems Div.**, Ann Arbor, Mich., for *Advent* satellite communication system modification.

$2,712,401—**Raytheon Co.**, Lexington, Mass., for marine concurrent repair parts, *Hawk* missile system. (3 contracts).

$818,000—**Fairchild Stratos Corp.**, Hagerstown, Md., for long range drone surveillance system.

$197,000—**Raytheon Co., Missile and Space Div.**, Bedford, Mass., for study of radar echo characteristics.

$133,000—**General Instrument Corp., Thermoelectric Div.**, Newark, N.J., for R&D to result in the fabrication of one experimental model and three development models, including manufacturers drawings and final technical report, of thermoelectric generators.

$93,829—**Texas A&M Research Foundation**, College Station, Tex., research for the continuation of work on the basic contract for improving, evaluating and extending the capabilities of a model of a meteorological simulator.

NAVY

$1,500,000—**Sperry Gyroscope Co.**, Syosset, Long Island, N.Y. for support and training equipment and services in connection with navigation subsystems for ballistic missile submarines.

$709,000—**Edward R. Marden Corp.** Brookline, Mass. for additional *Polaris* navigation and fire control system overhaul, Portsmouth Naval Shipyard, N.H.

$266,000—**B. F. Goodrich Aerospace and Defense Products**, Akron, Ohio for production of solid fuel motors for the *Loki* atmospheric sounding rocket.

MISCELLANEOUS

$2,800,000—**Hughes Aircraft Co.**, Culver City, Calif. from Raytheon Co. for work on *ARPAT*.

$2,400,000—**Avco Corp., Lycoming Division**, Stratford, Conn., from **Thiokol Chemical Corp.** for rocket motor cases for the *Dyna-Soar* Program.

$1,500,000—**Beckman Instruments, Inc.** from North American Aviation for electronic units to be used in the *Minuteman* checkout system.

$1,000,000—**Gulton Industries Inc.**, Metuchen, N.J. from Martin Co. for instruments and systems for the *Titan II* ICBM program.

$839,845—**ITT Communications Systems, Inc.**, Paramus, N.J. from the Defense Communications Agency for preparation of a simulation model of the Defense Communications System.

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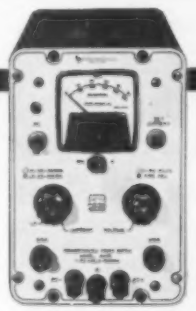

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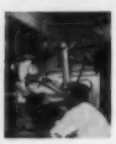

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Hardware?

Maybe connectors were "hardware" twenty years ago.

That's when the P-38 was the hottest fighter plane we had. Pilots were proud when they could hit 300 MPH and go up to 50 or 60 thousand feet. With this kind of performance requirement, most connectors worked without a hitch. You just connected them and forgot about them, like nuts and bolts.

HOW TIMES HAVE CHANGED

Now we're up around Mach 5 and altitude has been pushed into outer space. Nose cones light up like giant soldering irons and components have to operate in a near vacuum.

Fortunately, Amphenol engineers saw that the old "hardware" concept was headed out the window. Programs coming up were going to need connectors that could put up with terrific environmental conditions of heat and altitude cycling. For example, at high temperatures most of the elastomers used as insert materials or connector seals either melt into a puddle, turn into a cinder, or set-up and lose compression.

What's more, connectors now have to keep on functioning *all* the time, with no allowance for failure. So—Amphenol designers went to work developing a connector to meet the new space-age standards.

DISSECTING MOLECULES

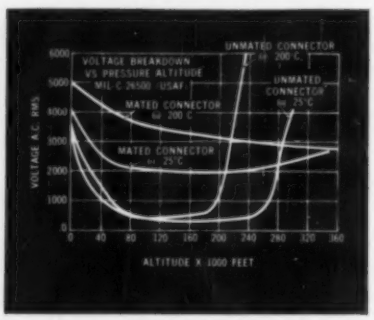
The Amphenol Materials Lab, with the help of a shiny new infra-red photospectrometer, began dissecting elastomer molecules. They were able to pinpoint the weak spots in molecular structure where breakdowns begin. Then they were able to plan and build new molecules, with built-in "armor" to protect against failure. Result: an exclusive silicone rubber compound that maintains its integrity and elasticity under severe temperature extremes and also withstands exposure to violent new propellants like hydrazine and nitrogen tetroxide.

At the same time, Amphenol design engineers were hard at work perfecting metal-to-metal shouldering of mating shells that allowed precision control over compression of the sealing ring. In addition, the metal-to-metal design damped vibrational stress nine times more effectively than resilient damping. Finally, they incorporated a semi-rigid anti-deflection disc to control insert expansion under thermal stress.

Having all the pieces, we put them together, called it the Amphenol 48 Series, and started testing. In the vacuum chamber, 48 Series connectors operate very nicely at a simulated altitude of 500,000 feet. They are quite comfortable in the hot box at 200°C ambient, *carrying full rated current.* They don't even mind going up to 600°C, if they don't have to stay too long. In short, Amphenol 48's can take almost anything you throw at them.

PROJECTS WANTED

Amphenol designers have established criteria for determining connector time-temperature-current capability. This information will be especially valuable to engineers presently engaged in "exotic" projects, perhaps the kind of project where previous connectors have failed to measure up to the new space-age standards. If this is the case, contact an Amphenol sales engineer. He's a "space-age hardware" expert. Or, write directly to Bob Dorrell, Vice President, Engineering, Amphenol Connector Division, 1830 South 54th Avenue, Chicago 50, Illinois.


VOLTAGE BREAKDOWN VS PRESSURE ALTITUDE MIL C 26500 USAF
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MATED CONNECTOR @ 200°C
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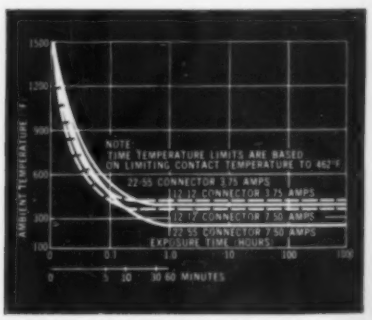
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12-12 CONNECTOR 3.75 AMPS
12-12 CONNECTOR 7.50 AMPS
22-55 CONNECTOR 7.50 AMPS
EXPOSURE TIME - HOURS
MINUTES

While Amphenol 48 Series Connectors are nominally rated at 200° C, they can also withstand considerably higher short-time temperature exposures.

Amphenol 48 Series Meets Mil C 26500 (USAF).

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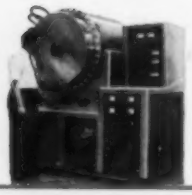

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